

**PHASE II GROUNDWATER INVESTIGATION REPORT
FOR THE
RMI EXTRUSION PLANT SITE**

SUBMITTED TO:



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EXECUTIVE SUMMARY

Sharp and Associates, Inc., (SHARP) and RMI Environmental Services (RMIES) performed Phase II of a Groundwater Investigation at the RMI Extrusion Plant Site (Site) in accordance with the approved work plans. This *Phase II Groundwater Investigation Report for the RMI Extrusion Plant Site* documents work performed at the site and compares the results obtained from this work to recent and historic Site groundwater data. The report comments on the Site and regional geologic setting, and evaluates the nature and extent of remaining Site contamination (and likely sources of that contamination). The report also identifies groundwater data gaps, compares all detected contamination against regulatory requirements and potentially relevant criteria, and provides recommendations for future work.

Table A summarizes the work performed during this phase of the investigation.

Table A. Summary of Activities Conducted in Phase II RMI Extrusion Plant Site Groundwater Investigation			
<u>Task</u>	<u>Amount</u>	<u>Summary of Activity</u>	<u>Data Available</u>
#1 Well Evaluation/Repair	7 wells	Replaced casing, installed drains	N/A
#2 Plug/Abandon Damaged Wells	17 wells	Abandoned damaged/compromised wells	Appendix B
#3 Install New Wells	16 wells	Installed replacement wells (for Task 2 wells) and new wells to fill data gaps.	Appendix A
#4 Well Sampling, Side by Side Sampling Test	14 wells	Sampled MW-101, MW-402, MW-901 through MW-909, MW-912, MW-913, MW-915	Table 11
#5 Pre-mob and Surveying	49 wells	Spotted new well locations. Surveyed entire well network.	Appendix E
#5a Measure water levels	48 wells	Data used for Potentiometric Mapping January and May 2003	Figs. 4.1, 4.1A, 4.2, 4.2A, 4.3, 4.3A
#6 Seep Mapping	12 seeps	Flagged and mapped seeps	Figure 3.11
#7 Hydraulic Testing	10 tests	Collected and analyzed Shelby tubes, conduct Slug tests	Table 2A, Appendix H
#8 Collect/Analyze Groundwater Samples	14 wells	Review of MW laboratory data	Table 10, Appendix J
#9 Utility Investigation Transect Soil Sampling	49 boreholes 120 samples	Borehole advancement, soil and groundwater sampling	Tables 7, 8; Figs 3.1 - 3.9 Table 9 / Fig 6.3
#9a Field XRF Readings	50 readings / lab samples	Record XRF results; compare to lab	Table 5
#9b MIPS Survey Readings	411 readings	MIPS survey run in conjunction with transects	Table 2
# 10 FEP WMU area Transect	9 boreholes	Borehole advancement, soil sampling	Figure 3.10
#11 Correlation between geology and contaminant concentrations in FEP WMU	NA	Prepared cross sections and isoconcentration maps to determine correlation between geologic units and contamination	Appendix I

As a result of this investigation, SHARP confirmed:

- Except for some near-surface soils, the site setting is one of generally low-permeability matrices;
- Migration of Site constituents of concern (COCs) via a groundwater pathway does not occur to any great extent;
- Trichloroethene (TCE) is the most mobile in groundwater of the principal Site COCs – more mobile than either Technetium-99 (Tc-99) and Uranium (Total U) and thus has the greatest potential to migrate from its source(s) via a groundwater pathway; and
- Most contamination is found in the vicinity of its source.

This investigation also determined that the 18-inch outfall lines that had been suspected to contain permeable backfill do not. The backfill consists of relatively impermeable native materials. The backfill acts more as a plug – potentially allowing contaminants to migrate along the contact with the plug. As a result, the *outfall pipe itself* may have been a significant conduit and contaminants may migrate along the backfill plug contact to the outfall line and *away* from the site, but the backfill around the pipe does not act as a major conduit.

Activities completed during Phase II of the site wide groundwater investigation for the RMI Extrusion Plant can be summarized as follows:

1. All of the monitoring wells scheduled for installation and abandonment were completed;
2. The well sampling and side-by-side testing of sampling methods have been completed, with the exception of monitoring wells (MWs) 900, 910, 911 and 914 which had not generated sufficient groundwater for sampling at the time of this report revision;
3. Seep locations at the swale and escarpment have been mapped and shown to correlate with the more permeable zones located near the Former Evaporation Pond (FEP) Waste Management Unit (WMU), previously referred to as the Corrective Action Management Unit (CAMU);
4. Groundwater flow is to the north/northwest in all units with a rate of migration on the order of 0.01-0.07 ft/year;
5. Investigation of the extent of contamination associated with the 18-inch outfall line was completed with the following results:
 - Twelve of the 51 soil samples exceed the 43 mg/kg standard for Uranium but most of these results are in the FEP WMU area, and only one of these is located at a depth greater than 5-feet;
 - One Tc-99 result slightly exceeds the soil standard of 65 pCi/g in the FEP WMU;
 - Only one TCE soil result exceeds the 22.6 mg/kg standard in one location (in the FEP WMU, near the surface); and
 - TCE in groundwater exceeds the 5 µg/L standard in the FEP WMU and in one other area located near the substation.
6. The extent of groundwater contamination as determined by the groundwater monitoring results are listed below:

- Total Uranium (U) exceeds the groundwater cleanup standard of 30 ug/L in the vicinity of the FEP WMU. Exceedances are limited to the till wells.
- Tc-99 exceeds the groundwater cleanup standard of 900 pCi/L in the vicinity of the FEP WMU. The plume is delineated within the till wells.
- TCE in groundwater wells exceeds the 5 ug/L standard is limited to the FEP WMU.

SHARP found that Site contamination does not travel far from its source(s) in the absence of conduits. As a result, strategies to remediate site media may need to be altered to best accommodate this condition.

The FEP WMU groundwater plume areas include surficial fill and silt lenses at shallow depths that allow migration of VOC and radionuclide contaminants via a groundwater pathway. The fill and silt lenses also seep and feed a ditch located at the top of the swale and seeps located on the face of the escarpment north of the FEP WMU. The seeps may allow migration of contaminants to lower Area C if not controlled (see Section 3.4 and Figures 1.1 and 3.11 for details).

1.0 INTRODUCTION

Sharp and Associates, Inc., (SHARP) performed much of Phase II of a Groundwater Investigation at the RMI Extrusion Plant Site (Site) in accordance with the approved *Work Plan for the Phase II Groundwater Investigation at the RMIES Main Extrusion Plant Site, Ashtabula, Ohio (dated September 10, 2002)* and *Work Plan for the Phase II Groundwater Investigation at the RMI Extrusion Plant (dated November 22, 2002)*. This Phase II work was a follow-on to the Phase I evaluation SHARP completed in 2002.

This *Phase II Groundwater Investigation Report for the RMI Extrusion Plant Site* documents work performed at the Site and compares the results obtained from this work to recent and historic Site groundwater data. The report comments on the Site and regional geologic setting and evaluates the nature and extent of remaining Site contamination (and likely sources of that contamination). The report also identifies groundwater data gaps, compares all detected contamination against regulatory requirements and potentially-relevant criteria, and provides recommendations for future work.

1.1 BACKGROUND

RMIES is working toward securing environmental closure at the Site. Figure 1.1 provides a Site map. RMIES contracted with SHARP to perform a groundwater investigation. Phase I of the groundwater investigation included: a review of documents related to Site groundwater information; inspection of Site wells; and review of potentially relevant data. The following conclusions are based on the work in Phase I:

- ***Site groundwater is typically present in very-low-permeability matrices.*** Contaminant transport within these matrices is slow; thus, contaminant transport beyond the source areas typically occurs via more-permeable conduits.
- ***The more permeable areas include:***
 - granular fill, typically found in the top 3-5 feet of soil;
 - silt lenses present in the oxidized portion of the native till;
 - utility lines and the utility backfilled areas; and
 - vertical soil fractures.

Roof drains historically extended from the Main Plant that discharge into an 18-inch effluent line and may explain some of the historic contaminant transport. Although both ends of this line have been plugged, there is still some potential for migration within the pipe between the plugged ends and to a lesser extent, through the utility line backfill. This effluent line (and its surrounding backfill) may have acted (and may continue to act to some degree) as a "French Drain" – dewatering a portion of the Site and allowing contaminants to preferentially transport along this conduit. This effluent line bisects the southern portions of the FEP WMU area.

- *The major source of Site contamination is the soil in the FEP WMU area* – a portion of the site that is contaminated with chlorinated solvents: trichloroethylene (TCE), tetrachloroethylene (PCE), and related constituents. This waste management unit has been identified in the in-place Resource Conservation and Recovery Act [RCRA] hazardous waste permit renewal for the site [OHD 980 683 544], dated August 13, 2002. In the permit, the only identified cleanup goal for this WMU is TCE at 22.6 mg/kg. The FEP WMU is also contaminated (from historic operations) with radiological parameters: Uranium (U) and Technetium-99 (Tc-99). There is an approved decommissioning plan that addresses the radiological parameters on the site; radiological decontamination and decommissioning activities are supervised by the Ohio Department of Health. *Affected groundwater associated with the FEP WMU* is identified as a separate WMU by Ohio EPA in the RCRA permit. The cleanup standard for TCE in groundwater is 5 µg/L.
- *The seepage pond at the base of the escarpment* (a 3rd WMU listed in the RCRA permit) has been remediated to meet radiological cleanup standards.
- *Another Area of Concern – the “L”-shaped area* has also been remediated to RCRA and ODH standards for lead and uranium.
- *Surface soils provide an additional source area at the site.* Soils within ~5 feet of the surface are contaminated with Total U and Tc-99, presumably due to deposition of airborne fine particulate from historic operations. These surface soils have the potential to contaminate groundwater with radiological parameters.
- *Lead and barium* are naturally-occurring constituents whose detection may also be associated with historic Site operations. Monitoring well construction and historic sampling methods may have caused some false-positive detections of these constituents (refer to the Sharp and Associates report for the *Phase I Groundwater Investigation at the RMI Extrusion Plant Site*, dated 7/22/02, for details). The in-place RCRA permit does not identify cleanup standards for barium or lead in water. The USEPA drinking water standard maximum contaminant levels (MCLs) will be used for screening purposes.
- There have been detections of barium and lead that exceed the MCLs in some of the wells. There is not a distinct pattern of these inorganics and most of the recent detections are believed to be related to methods that may not provide samples that are representative of groundwater. Natural background concentrations of these constituents may be responsible for some above-MCL detections. To evaluate this inference, side-by-side sampling using bailers and low flow techniques was conducted on selected wells.

1.2 INVESTIGATION SCOPE AND OBJECTIVES, PHASE II

The overall objective of the Phase II investigation is to fill in the data gaps (identified in Phase I) to define the nature and extent of groundwater contamination at the site. The primary COCs at the site include: TCE, Total U, and Tc-99. Additional potential site COCs include PCE, breakdown products of TCE and PCE (e.g., dichloroethene and vinyl chloride), lead, barium, and nitrates/nitrites. PCE's presence on site is attributed to its being a component of the 'technical

grade' TCE used as a degreasing agent during historic operations at the site. Although not reported during Phase I of the groundwater investigation, groundwater concentrations of nitrates/nitrites in some FEP WMU area wells exceed the MCL and may be considered a constituent of concern. This is based on historical sampling by Eckenfelder and recent sampling to support the bioremediation project.

The scope of work performed in this Phase II investigation is summarized below and in Table A.

Task 1. Evaluate Wells / Repair: One of the conclusions of the Phase I report was that there are potentially compromised wells at the site. A total of seven (7) wells were repaired in the Phase II field effort. The above-grade protective casing was replaced on MW-403. A section of the outer protective casing for MW-404 was found to be radioactively contaminated and thus was removed for disposal. In addition, drains were installed in the flush-mount vaults of MW-106, MW-801, MW-802, MW-803, and MW-804 to allow standing water to drain from the casing.

Task 2. Plug and Abandon Damaged Wells: The Phase I report identified a number of wells that were compromised and in need of abandonment. The following wells were abandoned during the field work; MW-100, MW-103, MW-104, MW-202, MW-204, MW-205, MW-206, MW-207, MW-301, MW-309, MW-310, MW-311, MW-312, MW-313, MW-500, MW-511, and MW-512. Water Well Sealing Reports, which document the closure of these wells are included in Appendix B of this report.

Task 3. Install New Monitoring Wells: A total of sixteen monitoring wells were installed as part of this investigation to fill data gaps and to replace wells that were damaged beyond repair or otherwise compromised. The wells were installed in the order of the potentially least contaminated to the potentially most contaminated. The order that the wells were installed is as follows: MW-910, MW-911, MW-913, MW-904, MW-908, MW-907, MW-914, MW-912, MW-906, MW-903, MW-905, MW-915, MW-901, MW-900, MW-902, and MW-909. Logs documenting the installation of these wells are included in Appendix A of this report.

Task 4. Sample Wells. Side-by-Side Method Test: Because some wells produce turbid samples when collected with a bailer, samples from these wells have the potential to yield results that may not be representative of site groundwater conditions. A side-by-side sampling test was conducted to compare bailer-collected samples to samples collected using low-flow techniques. The January 2003 samples were collected from the same well at about the same time. The May 2003 wells were bailed and sampled after sufficient time for groundwater recovery. MW-902 did not yield sufficient water for the bailed sample to be collected. Both filtered and unfiltered samples (collected using both techniques) were submitted to the laboratory for analysis. MW-101, MW-402, MW-901, MW-902, MW-903, MW-904, MW-905, MW-906, MW-907, MW-908, MW-909, MW-912, MW-913, and MW-915 were sampled during this side-by-side test.

Task 5. Conduct Premobilization Activities and Survey Afterward: Prior to beginning installation of the new MWs, an underground utility survey was completed per site

procedures to prevent damage to existing utilities from drilling operations. The well locations were physically staked based on the utility survey and drill rig accessibility. Following the completion of the new wells, the entire well network was surveyed for northing, easting, and elevation by Westfall Surveying of Jefferson, Ohio. In addition to surveying the MW network, Westfall completed a topographic survey of the FEP WMU area. The survey data are included in Appendix G of this report. The survey results, including the FEP WMU topography are depicted in Figure 1.1.

Task 6. Map Seeps: A SHARP field geologist mapped the silt seams along the escarpment to further define the Site hydrogeology. The seep locations were also surveyed.

Task 7. Conduct Hydraulic Testing: To address a data gap identified in Phase I, rising and falling head tests (slug tests) on the new wells are planned following their development. Slug tests were performed on wells MW-900 through MW-915. Additionally, ten Shelby Tubes collected during the well installation were laboratory tested for permeability following ASTM method D-5084 in order to support Site groundwater flow (hydraulic) interpretations. These results are presented in Section 4. Water levels were recorded on January 3, 2003, and in May 2003 and used to produce potentiometric surface maps.

Task 8. Collect and Analyze Groundwater Data: RMIES and SHARP sampled wells in the network (listed in Table A below). Many of the wells were slow to develop. Wells MW-900, MW-910, MW-911 and MW-914 did not yield sufficient water to be sampled.

Task 9. Investigate Utility Line and FEP WMU: The buried 18-inch outfall lines were identified in Phase I as a potential conduit for contaminant transport. The FEP WMU is a major source of Site contamination; and a portion of the utility line is located along the southern portion of the FEP WMU. The Utility Line and FEP WMU investigation was performed in order to:

- Further define the nature and extent of contamination in the vicinity of the line;
- Refine the lithology of the native materials located immediately outside the trench;
- Confirm the topography of the trench flank and of the gray/brown till interface;
- Define the hydraulic characteristics of the trench fill material; and
- Provide information to support development of appropriate methods to remediate these areas.

Task 10. Investigate the area of the FEP WMU, between the ditch area and the northern escarpment/swale: The water within this area has been sampled and reported to contain TCE and vinyl chloride. This contaminated water from the FEP WMU has the potential to migrate via both groundwater and surface water pathways. This water may potentially re-contaminate the Lower Area C. The potential for this to occur will remain until the upper portion of the site has been remediated or the transport pathways have been interrupted. The purposes of this portion of the investigation are to:

- Further define the relationship of the silt lenses within the oxidized till to groundwater and contaminant flow in this area; and

- Collect information that will support development of appropriate methods that RMIES may apply as interim control measures within this area to minimize the potential for Lower Area C recontamination until the final remedy is in place.

Task 11. Evaluate the correlation between geologic units and contamination in the FEP WMU. This task was conducted to determine whether the geologic subunits will be a field indicator of the occurrence of soil contamination in the FEP WMU. Geologic cross sections with the contaminants posted as well as isoconcentration maps of contaminants within the geologic units were prepared to evaluate the correlation.

Table A provides a summary of the testing conducted during Phase II. This report has been updated with the data received and compiled as of July 2003. Refer to Table 1 for a summary of the samples collected for analysis.

Table A. Summary of Activities Conducted in Phase II
RMI Extrusion Plant Site Groundwater Investigation

<u>Task</u>	<u>Amount</u>	<u>Summary of Activity</u>	<u>Data Available</u>
#1 Well Evaluation/Repair	7 wells	Replaced casing, installed drains	N/A
#2 Plug/Abandon Damaged Wells	17 wells	Abandoned damaged/compromised wells	Appendix B
#3 Install New Wells	16 wells	Installed replacement wells (for Task 2 wells) and new wells to fill data gaps.	Appendix A
#4 Well Sampling, Side by Side Sampling Test	14 wells	Sampled MW-101, MW-402, MW-901 through MW-909, MW-912, MW-913, MW-915	Table 11
#5 Pre-mob and Surveying	49 wells	Spotted new well locations. Surveyed entire well network.	Appendix E
#5a Measure water levels	48 wells	Data used for Potentiometric Mapping January and May 2003	Figs. 4.1, 4.1A, 4.2, 4.2A, 4.3, 4.3A
#6 Seep Mapping	12 seeps	Flagged and mapped seeps	Figure 3.11
#7 Hydraulic Testing	10 tests	Collected and analyzed Shelby tubes, conduct Slug tests	Table 2A, Appendix H
#8 Collect/Analyze Groundwater Samples	14 wells	Review of MW laboratory data	Table 10, Appendix J
#9 Utility Investigation Transect Soil Sampling	49 boreholes 112 samples	Borehole advancement, soil and groundwater sampling	Tables 7, 8; Figs 3.1 - 3.9 Table 9 / Fig 6.3
#9a Field XRF Readings	50 readings / lab samples	Record XRF results; compare to lab	Table 5
#9b MIPS Survey Readings	411 readings	MIPS survey run in conjunction with transects	Table 2
# 10 FEP WMU area Transect	9 boreholes	Borehole advancement, soil sampling	Figure 3.10
#11 Correlation between geologic subunits and contamination	Interpretation of existing data	Prepare cross sections and isoconcentration maps in the FEP WMU	Appendix I

2.0 UPDATED GEOLOGIC SITE SETTING

SHARP reviewed Site documents and performed a Site visit as part of the Phase I to evaluate the geologic setting and well conditions and compare them to similar site (and constituent) conditions that it has encountered in Northeast Ohio. Based on this work, the following conditions were found to be present at the site;

- The matrix materials of the till, the weathered shale, and the shale formations across the site have very-low-permeability. This limits both groundwater and groundwater-associated contaminant transport by way of typical groundwater pathways;
- Depth to first-encountered groundwater is typically only a few feet;
- Some wells do NOT provide samples that are representative of actual Site groundwater conditions due to damage, age, and/or remediation activities; these include well installations with near-surface bentonite seals subject to frost heave, long screen lengths that straddle more than one unit, the nearby presence of utility conduits, and heterogeneous surface water / groundwater interfaces;
- Constituent transport of more than a few feet likely occurs via atypical pathways; e.g., via surface water or storm water infiltration at conduit locations or groundwater transport through more-permeable zones (native and created); and
- Fill materials present at the surface have higher permeability than underlying natural strata and allow higher near-surface transport of constituents in groundwater.

To further elucidate Site conditions, SHARP and RMIES performed Phase II work as described in Section 1. The locations for the new wells were chosen to resolve questions about well completions, to determine if contaminants were present in outlier areas away from the FEP WMUs, and to further determine the characteristics of groundwater flow across the site. The Geoprobe® boring investigations were designed to determine if the utility trench between Manholes 1 (MH1) and 11 (MH11), and MH1 and MH2 are pathways for contaminant migration and to determine the extent of the silt lenses in the brown till across the northern boundary of the FEP WMU.

2.1 STRATIGRAPHY AND HYDROGEOLOGY

Topsoil/Fill:

The topsoil at the site has generally been described as having a high clay content that is derived from the Ashtabula Till. The permeability of this native topsoil is similar to the underlying tills below the root zone of plants. The topsoil/fill has characteristically high runoff and low percolation rates during (and shortly after) precipitation events.

Much of the site has been re-graded; some regrading where native material has been moved from high to low areas. During the drilling of the recent wells, Shelby tubes were pushed into the fill material as well as native material. Table 2 summarizes the hydraulic conductivity values found in the fill and in the native materials at different depths from the slug tests and Shelby tube samples. The results indicate that native materials are typically low-permeability materials, in a range of 10^{-6} through 10^{-8} cm/sec. This is consistent with previous work that generally found the hydraulic conductivity of the soil at 10^{-6} cm/s. (Summary Report of WIDE Soil Flushing, 1999).

Materials with this permeability will have the characteristics of low infiltration and high runoff. (Krynine and Judd, 1957)

The extensive use of crushed limestone and gravel as surface fill in some areas of the site has significantly altered the runoff/percolation balance in localized areas. Where this permeable material has been added, there is significantly less surface runoff and evaporation, making more water available for infiltration into the deeper sections over a longer period of time. The primary areas where this has been identified are:

- within the FEP WMU, around the L-series borings 1 through 11, 16, and 21 through 24); and
- the area around the CEI substation (borings for wells 909 and 913).

This gravel fill likely accounts for some of the increased volume of water produced from the subsurface in these areas.

Till:

The till stratigraphy of the Site has been extensively described in previous reports (Dames and Moore, 1985, Eckenfelder, 1989, AWARE, 1988). The results of re-evaluating those assessments, along with the additional data from the additional Phase II borings and wells, indicate that the glacial till unit should be subdivided into two subunits:

- an upper, oxidized, brown till that contains extensive silt stringers; and
- a lower, unoxidized, gray till that does not appear to have significant silt lenses.

The USCS classification for both of these subunits is CL, or clay. Soil profiling and grain size analysis were performed during the subsurface investigation by North Carolina State University (NC State University, 1999). The report found that the two clay till types were compositionally heterogeneous to a depth of about 8 feet and very homogenous from that depth downward. The heterogeneity in the upper section may be attributed to the backfill that was applied over the area as well as the silt lenses that are present in the upper section.

Within this subdivided depositional model, the major percentage of the water and contamination in the till can be shown to be constrained to the silts within the upper oxidized brown till subunit. The piezometric surface for the till units is at a depth of about 3 to 5 feet below grade. Below this depth, the till is saturated; but water only represents about 10 to 20 per cent of the total density of the till section because of the high overall percentage of clay throughout. Table 2 summarizes the initial saturation of the Shelby tube samples and also the percent water for the boring performed as part of the Phase II groundwater investigation. The only sample that was not saturated was the sample taken from 0-2 feet in boring MW-911, which is above the water table. A sample was taken from boring MW-902 in native material with some silt (4 to 6 feet) but was inadvertently remolded at the laboratory so that the silt and clay till were homogenized. The reported permeability of 10^{-7} cm/s for this sample represents the permeability of that homogenized sample and is not representative of the hydraulic conductivity of silt that is typically in the range of 10^{-3} to 10^{-5} cm/s (Applied Hydrogeology, 3rd Edition, C.W. Fetter, 1994).

A series of geologic cross sections were constructed to further illustrate the relationship between the brown oxidized till and the silt lenses within the till, the gray unweathered till, and the bedrock shale. Figure 2.1 is a base map with the trace and well boring locations used to construct these cross sections.

Figure 2.2 is a north-south cross-section and Figure 2.3 is an east-west cross-section. The locations of silt sections within the till have been documented on these sections where existing boring logs allow. Figure 2.2 has also been modified to include the location and depth of the 18-inch effluent line that bi-sects the Site. Figures 2.4 and 2.5 are new cross sections to provide further information in vertical view across the site, and are constructed to link more of the Phase II boring data with existing logs.

Oxidized Brown Till:

Based on information from the monitoring wells that were installed as part of this Phase II investigation (Wells 900 through 915), the Geoprobe® investigations along the utility trench (Transects 1 through 9), and a re-examination of the existing logs from historic borings and wells, there appears to be strong evidence that the silt intervals present in the till are primarily within the oxidized brown till section as described above. Our review of a published geologic report on the tills in Ashtabula (Glacial Geology of Northeastern Ohio, George White, 1982) indicates that this interpretation conforms to the published regional geologic deposition of the Ashtabula and the Hiram Tills. The silt intervals have lower clay content than the till, and likely represent a beach of an earlier lake episode that washed and reworked the till, as described in the physiography section of an earlier assessment report (Eckenfelder, 1989).

Based on a review of the soil borings and wells, there is a high correlation between the presence of contamination and the presence of silt lenses. The silt lenses are generally limited to the brown till subunit. In the investigation performed by NC State (1999) they found that in the area of the borings that they drilled, the major part of the contamination was at depths of 5-9 feet. The exception was in Boring T5 where they found TCE 16 feet. Tc-99 was found at relatively the same depths. Uranium was found to be present at shallower depths (at 3 feet in boring T3).

The Geoprobe® transect of borings that were collected across the north side of the FEP WMU has shown that these silt lenses are present along the escarpment and have the potential to become seeps following rain events. The surface ditch located north of the FEP WMU, at the top of the swale, may also be fed by one or more seeps, both through the surficial gravels and deeper silts present over some of this area. The ditch contents have been sampled and have reportedly been found to contain volatile organic compounds (VOCs) and Total U. This ditch can potentially overflow during a rain event and may allow transport of any contaminants present therein down the escarpment.

In addition, seeps along the escarpment have the potential to allow transport of contaminants down the escarpment and re-contaminate previously-remediated areas. A preliminary visual estimate of the seeps along the escarpment indicated that the discharge is intermittent, and may be a combination of surface discharge from the ditch north of the FEP WMU and seepage from the silts within the brown till. There is a more detailed discussion of the seeps in Section 3.

Figure 2.6 is a structure map of the surface of the gray till. The topography of this surface likely influenced the location of the silts in the brown till and to some extent their thickness. The major features of this map are the high area in the south part of the main plant building slab and the drainage feature underneath the FEP WMU.

Figure 2.7 is a net isopach map that portrays the combined thickness of the silts in the brown till. The trend of the thickness indicates that silt lenses are present within the brown till over the entire site. They are generally greater than 6 feet thick in the east, and thin to the northwest where they are less than 1 foot thick. The thickness of the silt lenses in the area of the FEP WMU is variable, but generally thicker across the north and south sides.

Figure 2.8 is a structure map of the base of the silt lenses, portraying the lowest elevation that silt occurs within the brown till. The area of contouring is specific to the FEP WMU area and the trench of the utility line connecting MH1 and MH11. The trend of the silt is to deepen from the FEP WMU to the east, with the deepest area along the north side of the utility trench and around abandoned monitoring well MW-210.

There are numerous descriptions from borings across the Site that describe a high density of iron-stained fractures in the interval from 2 to about 15 feet, which is primarily in the oxidized brown till. Although these fractures may significantly increase the *vertical* permeability of the till locally, *there is no evidence* in the data from the Phase II borings and wells *that these fractures significantly affect horizontal contaminant transport*. The FEP WMU is an area where there is a high density of wells and borings in a small area, and the depth of fractures cannot be correlated from one boring to another.

Unoxidized Gray Till:

The gray till has had little exposure to water and air after historic deposition, and thus, apparently represents the uppermost portion of the Hiram Till. The Ashtabula Till is essentially Hiram Till scraped from the lake bottom by an ice advance and redeposited a few miles south (White, 1982). The lower gray till has few silt lenses, and when encountered in the new borings, lenses were characterized as less than 1 foot thick, with no free water.

There are vertically-oriented fractures that extend into the upper part of the gray till which may provide a mechanism for localized vertical contaminant transport from the overlying brown till and silt lenses into the top of the gray till. There is no evidence, however, that these fractures are interconnected to the extent that they influence contaminant flow horizontally. A review of the well and boring logs across the site indicate that the fractures occasionally extend to a maximum depth of 14 to 15 feet below grade (MW-907, MW-403, MP-10, MP-11, SB-2).

Shale and Interface:

The Chagrin Shale directly underlies the till and is several hundred feet thick. It is comprised of dark gray, dense shale with thin interbeds of fine grained siltstone and sandstone. There is a weathered zone (Interface) at the top of the shale that several of the monitoring wells are completed in. Based upon the permeability testing reported by Eckenfelder (1989), the shale section has lower permeability than the overlying tills.

The weathered interface zone is thin or absent in the deep 900 series borings (900, 902, 912, 915). The interface section is also considered to be a low-permeability stratum.

2.2 PRELIMINARY INTERPRETATION OF POTENTIAL TRANSPORT MECHANISMS

The primary source of Site contamination has been identified as the FEP WMU – an area historically contaminated with radiological parameters (Total U and Tc-99) and chlorinated solvents. Based upon the work completed during Phase I and Phase II of this investigation, there are limited mechanisms for the significant transport of contaminants from source areas (including the FEP WMU). The mechanisms for contaminant transport are summarized as:

- Localized areas where coarse material has been used for fill. These areas are likely creating more infiltration of surface water into the upper brown till; and within limited areas this changes the runoff/infiltration balance when compared to native materials. The FEP WMU is one area where this has been identified from existing and new borings and is likely contributing to the water in the ditch across the northwestern side of the FEP WMU. A second coarse fill area is located in the vicinity of the CEI substation.
- The silt lenses in the brown upper till subunit likely provide a pathway for migration to the escarpment and possibly along the utility trench south of the FEP WMU. Although silt is generally considered to be low permeability, at this site, it is the most permeable native matrix material and thus the most likely path of contaminant migration away from the FEP WMU.
- The vertical fractures found throughout the brown till and the top part of the gray till may provide a pathway for localized vertical migration as they provide a conduit for contaminants to migrate from the silt lenses in the brown till into the top of the gray till. There is no evidence that the fractures are interconnected and provide a viable pathway for horizontal migration within the till subunits.
- The numerous penetrations in the shallow sections of the FEP WMU (prefabricated vertical drains, HRC injection points, wells screened across various features, boring locations, re-grading, etc.) may allow migration of CoCs via more permeable conduits.

3.0 FIELD INVESTIGATION, SEEP MAPPING, AND SAMPLE COLLECTION

The Phase I investigation identified the potential for contaminant transport via conduits. Two areas of concern are:

- buried 18-inch outfall line that runs through the southern portion of the FEP WMU and eastern half of the site; and
- seeps located north of the FEP WMU near the escarpment.

SHARP and RMIES investigated these potential conduits in a "Geoprobe®" investigation conducted in accordance with the approved work plan.

3.1 BACKGROUND, INVESTIGATION, AND OBJECTIVES

Background, 18-inch Outfall Lines:

Recent samples collected at the RMIES NPDES outfall have contained concentrations of TCE above permitted discharge limits. In response to these results, RMIES plugged the 18-inch outfall lines between MH1 and MH11, and MH2 and MH1 in August 2002 and re-routed the wastewater flows to limit further release of TCE. However, water samples collected in the outfall line after the line was plugged still contain detectable concentrations of TCE. The outfall line investigation was conducted to identify possible source(s) and extent(s) of TCE contamination in the vicinity of the 18-inch outfall lines.

Previous investigations at the site (i.e.; underground utilities map, D-00248-T-01) have identified above-background concentrations of Total U in soil borings located in close proximity to buried utilities and building foundations. SHARP and RMIES suspected that these elevated concentrations could be the result of utility backfill material providing a preferential path for the vertical and horizontal transport of contaminants. The utility investigation sought to investigate the extent of contamination and the nature of the backfill material associated with the outfall lines located between MH1 and MH11 and MH1 and MH2. Nine sets (transects) of boreholes were advanced during the investigation of the outfall lines.

Utility Investigation:

The investigation included:

- advancement of Geoprobe® Macro-Core® samplers;
- collection of 3-foot acetate-liner-enclosed samples;
- description of the subsurface lithology;
- screening of the Macro-Cores® using a PID and Geiger-Mueller meter;
- collection of Encore® samples, analyzed for VOCs;
- Membrane Interface Probe (MIP) characterization;
- screening of samples with an XRF; and
- collection of samples for laboratory analysis of radiological parameters.

MIP Characterization:

In parallel with the collection of soil borings along the outfall lines, the Geoprobe® was outfitted with a MIP operated by personnel from the DOE's Savannah River Technology Center. The MIP provides for real time detection of total VOC concentrations versus depth. The results of this investigation are detailed in Appendix D. A summary of the MIP data is also presented in Table 3.

The MIP survey utilized a photoionization (PID) detector, and a Bruel & Kjaer photoacoustic analyzer that are useful for delineating relatively high concentrations of unspeciated VOCs. Although no VOCs were detected using the MIP along the 18-inch outfall lines, the MIP could be used to delineate VOCs present at levels near the TCE soil cleanup level. Some modification to the MIP may be required to obtain the sensitivity needed for this purpose. The MIP outfitted with a gas chromatograph has reported VOC detection limits of ~50 ppb in groundwater. Use of the machine in this mode could result in savings of laboratory costs as well as provide immediate data analysis.

SHARP and RMIES conducted the Geoprobe® portion of the investigation from December 3, 2002, to January 31, 2003, in accordance with the approved work plan. Ten transects of borings were installed: Transects 1-9 and the FEP WMU Transect. Due to conditions encountered in the field, the following modifications were made to the plan:

- MIP borings were installed in the A, B, C, and D locations on Transects 1 and 6.
- MIP borings were installed in the C and D locations of Transects 2, 3, 4, 5, 7, 8, and 9.
- Due to the interpreted (smaller than expected) width of the utility trench, the distance to the B and E borings was 6-feet from the centerline of the trench and the distance from the center of the trench to the A and F borings was 10-feet in transects 2, 3, 4, 5, 7, 8, and 9.

Background, Seeps Located North of the FEP WMU:

Seeps present along the face of the escarpment may allow contaminated groundwater to migrate via a surface water pathway to the Lower Area C. The investigation sought to identify the locations of these seeps and attempt to correlate them with the more permeable subsurface zones north of the FEP WMU area. One transect of boreholes was installed north of the FEP WMU area (North FEP WMU Transect). The lithology was logged and the locations of site seeps were mapped.

3.2 UTILITY LINE TRANSECT CROSS SECTIONS

The results of the lithologic descriptions of the borings were combined to generate geologic cross sections for Transects 1 through 9. These are presented in Figures 3.1 through 3.9 and discussed in the next section. Note that the higher permeability zones are shown in blue (sand, silt, gravel).

Geologic Cross Section of Transect #1 (See Figure 1.1 and Figure 3.1)

Transect #1 is located 60-feet east of MH11, south of the FEP WMU. The top three feet is fill material consisting primarily of gravel and silty clay. The deepest point of backfilled material associated with the 18-inch outfall line was found at 12.2-feet in BH1C. The trench backfill

material consists of a heterogeneous mixture of black, gray, and brown silty clay with varying amounts of sand and gravel as a minor component. No more-permeable (sandy/granular) pipe bedding was found in the base of the "trench" (the area apparently excavated and backfilled during installation of the outfall line).

Native materials were first encountered in the A, B, E, and F borings at ~3-feet bgs. South of the trench, a thin layer of organic clay (likely the topsoil present at the site prior to adding fill to the site surface) underlies the uppermost (gravelly) fill. This layer of "topsoil" was absent on the north side of the trench in this transect. Mottled brown and gray silty clay underlies the former topsoil and extends to nominally 6-feet bgs. Brown glacial till consisting of silty clay with sand and gravel as minor components extends to nominally 11-feet bgs. This till typically contains intermittent fractures with iron precipitates. Underlying the brown till is gray till consisting of silty clay with sand and gravel as minor components. Intermittent fractures containing iron precipitate were observed as deep as 14-feet bgs. Field screening with the hand held PID detected VOCs in the fractures as deep as 14-feet bgs north of the centerline of the trench. The field and laboratory data are presented in Tables 4 through 9. The field data are also presented on the boring logs in Appendix C.

A water sample was collected from a temporary piezometer that was installed from 3-feet to 8-feet bgs in a borehole offset 1 foot west of BH1B. The analytical results of the water sample are presented in Table 10. The water encountered in this borehole was from a perched zone at the contact between the top three feet of fill and the mottled brown and gray silty clay. The brown and gray mottled silty clay apparently acts as a confining layer preventing the vertical migration of groundwater. Water-producing deposits were not present in native materials or trench backfill in any of the Transect 1 boreholes at depths beneath this confining layer.

Geologic Cross Section of Transect #2 (See Figure 1.1 and Figure 3.2)

Transect #2 is located 150-feet east of MH11. Due to time constraints, boreholes A, E, and F were not completed. The geologic data collected from the B, C, and D boreholes are suitable to accurately define the geometry of the section. Trench backfill extended to 4-feet bgs in boring D and 7-feet bgs in boring C. Fill material consisting of gravel and silty clay extended to 3-feet below ground surface in boring B. The bottom depth of the trench on this cross section has been interpolated to nominally 12-feet bgs based on the estimated invert elevation of the 18-inch outfall. The fact that the C and D borings missed the bottom of the trench indicate a narrow trench with steep banking at this transect location. Trench fill material consists of heterogeneous mixture of gray and brown silty clay with varying amounts of sand and gravel as a minor component. No potential water producing zones were identified in the trench backfill.

Native undisturbed soils were encountered in boreholes B and D at 3-feet bgs. and 4-feet bgs respectively. A silt lens is present from 5.5-feet to 7-feet bgs in BH2B. This lens is not continuous across the profile and was not identified in BH2D, south of the trench. However, an increase in the moisture content of the silty clay was identified at a similar depth interval (7.0-feet to 7.6-feet bgs) in BH2D. A groundwater sample was collected from a piezometer offset 1-foot east of BH2B. The screened interval was set between 4-feet and 9-feet bgs to isolate the saturated silt lens.

Geologic Cross Section of Transect #3 (See Figure 1.1 and Figure 3.3)

Transect #3 was located 265-feet east of MH11. Across the section, surface fill consisting of aggregate base above silty clay with sand and gravel as a minor component was identified up to 3.5-feet bgs. The deepest trench backfill, encountered in boring D, extended to 9.5-feet bgs. The bottom of the trench has been projected on Figure 3.3 to 11-feet bgs based on the suspected depth of the 18-inch outfall line at this location. Trench backfill material consisted of a heterogeneous mixture of brown and gray silty clay with sand and gravel as a minor component. The moisture content increased with depth; however, no potential water producing material (silt/sand containing free water) was identified in the backfill.

Topsoil was identified beneath the surface fill on the north side in borings A and C. A layer of mottled brown and gray silty clay is intercepted by the trench and extends across the cross section. Underlying this unit is a lens of saturated silt that thickens to the north. The silt lens was identified from 6.0-feet to 7.2-feet bgs (1.2-feet thick) in boring F and from 4.7-feet to >9.0-feet bgs in boring A (>4.3-feet thick). The silt lens does not appear to be hydraulically connected north and south of the trench due to the less permeable trench backfill materials that intercept this unit. Brown silty clay (till) was identified beneath the silt unit on the south side of the transect to a depth of nominally 10-feet bgs. On the north side of the trench, the silt is underlain by gray clay and gray silty clay (till). Both the brown and gray tills identified beneath the silt have significantly lower moisture content than the silt unit and appear to act as confining layers.

A groundwater sample was collected from the saturated silt unit from a temporary piezometer installed in BH3C. The screen interval was set from 6-feet to 11-feet in the saturated silt from 7.2-feet to 10.5-feet bgs.

Geologic Cross Section of Transect #4 (See Figure 1.1 and Figure 3.4)

Transect #4 is located 360-feet east of MH11. Surface fill, consisting of aggregate base brown silty clay was identified to a depth of 1.7-feet on the north side of the trench and extended to 4.5-feet bgs on the south side of the trench. Refusal was encountered in boring F at 4.5-feet bgs on what is assumed to be the footer of a former structure. Trench backfill extends to a maximum depth of 16.1-feet bgs in boring D. A layer of black stained silty clay is present beneath the backfill in this boring from 16.1 to 16.4-feet bgs. Pipe bedding was not found in the bottom of the trench. Backfill material consists of brown and gray silty clay with sand and gravel as a minor component. A layer of gravel fill is located from 6.4 to 7.3-feet bgs in the fill material in boring C. Topsoil was identified beneath the surface fill in borings A, B and E. A continuous layer of mottled brown and gray silty clay underlies the surface fill and topsoil and extends to a maximum depth of 6.6-feet bgs in boring E. A thin lens of saturated silt is present in borings B and E and is likely in hydraulic communication with the gravel identified in the fill material in boring C, based on similar depth intervals. A confining layer consisting of brown silty clay (till) is present beneath the silt lens to a maximum depth of 9.3-feet bgs. The brown till is underlain by gray silty clay (till).

A groundwater sample was collected from a temporary piezometer installed in BH4B. The screen interval was set from 7-feet to 12-feet bgs and included the silt lens found in this borehole from 6.3 to 8.1-feet bgs.

Geologic Cross Section of Transect #5 (See Figure 1.1 and Figure 3.5)

Transect #5 is located 500-feet east of MH11. Aggregate base fill is present across the section up to 0.9-feet bgs. The maximum depth that fill material was encountered was 4.5-feet bgs in boring E. Trench backfill material was not encountered in this transect. Because of the presence of a shallow utility pipeline at this transect location, boring C was offset 4-feet north of the trench. The absence of trench backfill material in borings C and D suggests that the trench had little slope when the pipe was installed and the maximum width at the top of the trench was less than 6-feet.

Native materials encountered across the transect consisted of brown and gray mottled silty clay to a depth of nominally 3.8-feet underlain by a saturated silt layer to a maximum depth of 6.3-feet north of the trench and 9.0-feet south of the trench in boring D. Underlying the saturated silt is brown silty clay till over gray silty clay till. Both the brown and gray tills are significantly less permeable than the saturated silt and are likely acting as confining layers.

A groundwater sample was collected from a temporary piezometer installed in boring D with a screen interval of 6-feet to 11-feet.

Geologic Cross Section of Transect #6 (See Figure 1.1 and Figure 3.6)

Transect #6 is located 24-feet northeast of MH1 in Area D. Four of the six proposed borehole pairs (MIP and Macrocore) were installed (BH6A through BH6D). Boreholes BH6E and BH6F were not installed due to the presence of buried utilities. Fill material was encountered in all 4 borings and ranged in depth from 8.5-feet below ground surface (bgs) to 10.9-feet bgs. The fill material consists of a heterogeneous mixture of silty clay containing varying amounts of sand and fine gravel. Pipe bedding was not found in this transect. The geometry of the trench (wide and deep) suggests that the fill is associated with the excavation and removal of the former outfall pipe in Area D.

An increase in moisture content was identified at the base of the fill material. The silty clay matrix is defined as “moist to wet” in these samples. It should be noted that “moist to wet” is a qualitative description that indicates that the moisture content of the silty clay is between the plastic limit (PL) and liquid limit (LL) as defined in ASTM D-4318 and does not suggest that this material contains free water. Because there was no free water in any of the transect 6 boreholes, a temporary piezometer was not installed.

Geologic Cross Section of Transect #7 (See Figure 1.1 and Figure 3.7)

Transect #7 is located 64-feet southwest of MH1 on the RF-3 pad. The concrete floor slab, 0.75-feet thick, was cored with a nominal 4-inch core bit at each of the boring locations. Surface fill consisting of brown and gray silty clay extends across the cross section to a maximum depth of 3.0-feet bgs. The deepest trench backfill was identified in boring C at 9.7-feet bgs. Trench backfill material consists of a heterogeneous mixture of brown black and gray silty clay with sand and gravel as a minor component. Saturated sand was present within the trench backfill in boring C from 1.4-feet to 3.9-feet bgs and in boring D from 3.7-feet to 6.0-feet bgs. No pipe bedding was identified in the trench.

Native materials consist of brown and gray mottled silty clay to a maximum depth of 4.5-feet bgs in boring E. A continuous lens of saturated brown silt is present in borings A, B, E, and F and ranges in thickness from 1.1-feet in boring F to 1.7-feet in boring B. This saturated silt lens is likely hydraulically connected to the sand located in the trench backfill due to similar depth intervals. The maximum depth at which the saturated silt was encountered was 6.0-feet in boring E. A layer of brown silty clay (till) is found beneath the silt lens southeast of the trench backfill and a layer of highly plastic clay (fat clay) northwest of the trench backfill. Both act as relatively impermeable layers (confining layers) and have considerably lower moisture content. The brown till is underlain by gray silty clay starting at 6.3-feet southeast of the trench. Northwest of the trench, brown till underlies the fat clay from 7.2-feet to 9.0-feet. Gray silty clay till is found below 9.0-feet.

A groundwater sample was collected from a temporary piezometer installed in boring B and screened from 6-feet to 11-feet. Because of poor water recovery, only VOC samples were collected from this piezometer.

Geologic Cross Section of Transect #8 (See Figure 1.1 and Figure 3.8)

Transect #8 is located 112-feet southwest of MH1. The total depth of surface fill across this transect ranges from 2.3-feet in boring F to 7.0 feet in boring B. This variation is most likely the result of excavations related to other utilities and building foundations. The trench backfill material was identified to a maximum depth of 13.5-feet in boring D and consists of a heterogeneous mixture of soft black brown and gray silty clay with fine to coarse sand as a minor component. Moisture content ranges from moist to wet (i.e. >PL to >LL). Pipe bedding was not found in the bottom of the trench. A temporary piezometer was installed in the fill material of boring D from 8-feet to 13-feet. This piezometer did not produce water and could not be sampled.

Southeast of the trench, a saturated silt lens was encountered from 3-feet to 4.3-feet. A similar saturated silt lens was identified in boring A, northwest of the trench from 3.9-feet to 4.6-feet. Prior to excavation for the trench and other utilities/building foundations, these silt lenses were likely a locally-continuous unit.

Geologic Cross Section of Transect #9 (See Figure 1.1 and Figure 3.9)

Transect #9 is located 190-feet southwest of MH1. Surface fill, consisting of aggregate base is encountered across the entire section up to 1.7-feet. Trench backfill material was encountered up to 14.7-feet bgs in boring D and consists of a heterogeneous mix of soft, dark gray clayey silt to 12.0-feet. Gray and black silty clay containing decomposed organic material was present from 12.0-feet to 14.7-feet. The fill material is saturated below 6.0-feet.

Native materials consist of mottled brown and gray silty clay and brown clay to a maximum depth of 4.3-feet. A saturated silt lens, ranging in thickness from 3.8-feet in boring A and thinning to 0.5-feet in boring F is present in native materials across the transect. Beneath the silt lens, in borings located northwest of the trench, gray silty clay (till) is present at nominally 8-feet bgs. Brown silty clay underlies the silt lens southeast of the trench to a maximum depth of 8.2-feet where gray till is encountered. Both the brown and gray silty clay have significantly lower moisture contents than the overlying silt and likely act as confining layers.

A groundwater sample was collected from a temporary piezometer installed in the fill material of boring C. The screen interval was set from 6-feet to 11-feet to straddle the section in this boring where the most water was observed during boring installation. Due to poor recharge, only enough sample volume for VOC analysis was collected.

3.3 NORTH FEP WMU TRANSECT

Nine Geoprobe® borings were installed north of the FEP WMU (North FEP WMU Transect) to document the lithology and potentially identify the presence of saturated/permeable soils between the FEP WMU that may be sources of seeps from the face of the escarpment north of the FEP WMU. The location of these boreholes is shown on Figure 1.1. Figure 3.10, North FEP WMU Transect, was developed using the lithology encountered in BH11, BH12, BH14 - BH20, and MW-901. The distance between each boring is nominally 10-feet. BH13 was not completed because the location was inaccessible for the Geoprobe® due to surface topography.

Fill material is present across the majority of the transect ranging from 1.1-feet to 3-feet and is absent in BH14 and BH15. The one exception is boring BH17 where fill was present to a depth of 7.5-feet. West of BH17, brown and gray mottled silty clay is present to the maximum depth of 6.0 feet. A saturated silt lens is present in BH12, BH14, BH15, and BH16. The maximum thickness of this saturated silt is 2.5 feet in BH15. Following removal, water was observed on drill rods and sample barrels in borings where this silt deposit was present.

A thin silt lens is present east of BH17 in BH19, MW-901 and BH20. The maximum thickness of this deposit is 0.9-feet in MW-901. Brown silty clay till is present across the cross section generally at depths greater than 5-feet. Underlying the brown till is gray silty clay till, generally encountered at depths greater than 7.6-feet. Groundwater was not present in samples collected in the brown and gray till.

3.4 SEEP MAPPING

October 2002 Examination

SHARP conducted a field survey of the escarpment north of the FEP WMU on October 7-8, 2002, after recorded precipitation on October 5, 2002 of 0.06 inches. During this survey, locations were flagged near the top of the swale on the escarpment where there was an active seep or evidence of an active seep. Potential seeps located near the base of the escarpment were also noted and flagged. These location flags were later numbered and surveyed.

The areas around the active seeps were typically iron-stained and had accompanying algal bloom on the surface, around the riprap that had been placed in the swale (following remediation of radiologically contaminated soils by RMIES and SHARP in 2002). The uppermost seep locations (flag numbers 3 and 4) are located at the interface between fill and native clay noted in the escarpment excavation and the native material and had an observed flow of about ½ liter per minute. The exact location of the seeps at flags 1 and 2 were harder to define because they are located in the riprap covering the escarpment and generally had low flows (estimated to be on the order of only several cc's per minute at the time of observation). There were no obvious cracks or openings in the clay located behind the riprap at these locations.

Locations 5 through 9 were flagged at the base of the escarpment where there was a slope break, vegetation change, and indirect evidence of seepage. At the time of observation, no open flow was present. Locations 10, 11, and 12 were flagged in an area at the base of the escarpment where there was a vegetation change and indirect evidence of seepage without open flow. All of the flagged locations are shown on Figure 3.11.

Cross sections A-A' (Figure 2.2), D-D' (Figure 2.5) and the North FEP WMU Transect (Figure 3.10) show the relationship of Seep Locations 1 through 4 to the geology, in plan view. Cross section A-A' shows that seep locations 3 and 4 (which had open flow at the time of observation) are at the same elevation as the sandy silt lens encountered in well borings MW-209, 303, 306, and 307. Cross Section D-D' indicates that these same seeps are also co-incident with the silt described in well boring 900, which was drilled as part of this Phase II investigation. Nine Geoprobe® borings were drilled along this transect to further define the silt lenses and other possible saturated lithologies in the brown till subunit. The section of this transect (Figure 3.10) indicates that seep locations 1 and 2 are at the same elevation as the interface between the base of the fill encountered in BH-17 and the native brown silty clay.

Cross sections E-E' (Figure 3.12), F-F' (Figure 3.13), and G-G' (Figure 3.14) are detailed sections across the FEP WMU to further show the relationship between the silt lenses in the till and the seep locations. Each of these sections run South to North and tie to the Geoprobe location on the North FEP WMU Transect. Section G-G' traverses through BH-17, which is the closest location along the North Transect to the mapped seep locations. This section shows that seeps flagged as "3" and "4" are at the same elevation as the silt lenses found in boring L-19, and at the same elevation as a "wet" zone in the fill as logged in Borehole BH-17 along the North Transect.

On November 2, 2002, RMIES attempted to collect seep samples during a rainfall that totaled 0.19 inches. However, there was insufficient seep flow during this event to collect the minimum sample volume and therefore the collected samples consisted of seep water mixed with surface runoff. One sample was collected near seep flags 1 thru 4 at the top of the swale. A second surface runoff sample was collected in the swale halfway down the escarpment.

May 2003 Follow Up Examination

On May 22nd 2003 and May 27th 2003 the escarpment was again examined to determine the influence of runoff and seeps on the ponded water at the base of the escarpment. There was 0.32 inches of precipitation on May 21st and 0.53 inches of precipitation on May 24th, 2003. The precipitation data is measured at the plant outfall for the site's NPDES monitoring program. During these examinations it was determined that the water flowing down the escarpment was originating from 3 areas, as shown on Figure 3.11.

It was estimated that at the time of the examination, greater than 90 % of the water was coming from surface water runoff from Area 1, the ditch in the FEP WMU, and Area 2, the low lying areas east of the ditch but in the same general area of the FEP WMU. Area 3 was a smaller area further to the east, adjacent to the FEP WMU area and off the corner of the soil staging pad where there was seepage observed from the sloping surface. These areas are identified on Figure 3.11, and the surface flow is to flags 3 and 4. At the time the escarpment was examined it could

not be determined if there were additional seeps that contributed to the volume of flow at flags 1 and 2, as these were covered with surface flow from further up the escarpment. A water sample was collected at flagged location 4, and consisted of water that had consolidated from the 3 areas described.

Flagged locations 5 through 9 were under standing water during the time periods that the escarpment was examined and could not be evaluated.

Locations 10, 11, and 12 were previously flagged in an area at the base of the escarpment where there was a vegetation change and indirect evidence of seepage without open flow. During the examination on May 22, 2003, it was determined that there was a drainage gully on the slope above these flags concealed by vegetation, and that the wet soils at this location were caused by runoff from the surface area above the escarpment. The drainage course is shown on Figure 3.11.

3.5 SOIL SAMPLE COLLECTION DURING THE GEOPROBE INVESTIGATION

Following the completion of each Macro-Core® boring, the acetate liners containing the soil cores were taken to an on-site laboratory where the liners were opened in the order from shallowest to deepest drive interval. Information on lithology including color, predominant soil type, minor components, density, and moisture content were recorded in a field book. RMIES sampling technicians screened the Macro-Core soil samples with a Thermo-Environmental 580B Photoionization Detector (PID) and recorded the readings in 1-foot intervals on a field log (See Table 4). The entire length of the cores was screened with a Geiger-Mueller frisker and the location on each core with the highest response was screened to determine the counts per minute (cpm). These data were recorded on a field log. Soil sampling locations for laboratory analysis of VOCs were selected based on the highest PID readings in each borehole. In borings where PID readings were at background, soil sample locations were biased towards visible signs of contamination, the base of the fill material, soil directly beneath saturated silt lenses, and the invert elevation of the outfall line.

Three En-Core® soil samples were collected at each sample location and sealed in a single zipper bag. The borehole, depth interval, and time of collection were recorded on the label and on RMI chain of custody forms. Samples were collected for x-ray refraction (XRF) screening and submission for analysis for Tc-99 and Total U from the soil immediately above and below the En-Core® sample location. En-Core® samples were collected from a total of 91 locations. Total U and Tc-99 samples were collected from 107 locations.

3.6 MONITORING WELL INSTALLATION, REPAIRS AND ABANDONMENT

Sixteen monitoring wells were installed as part of this investigation to fill data gaps and to replace wells that were damaged beyond repair or otherwise compromised. The wells were installed in the order of the potentially least contaminated to the potentially most contaminated. The order that the wells were installed is as follows: MW-910, MW-911, MW-913, MW-904, MW-908, MW-907, MW-914, MW-912, MW-906, MW-903, MW-905, MW-915, MW-901,

MW-900, MW-902, and MW-909. Logs documenting the installation of these wells are included in Appendix A of this report.

Seven (7) wells were repaired in the Phase II field effort. The above-grade protective casing was replaced on MW-403. A section of the outer protective casing for MW-404 was found to be radioactively contaminated and thus was removed for disposal. In addition, drains were installed in the flush-mount vaults of MW-106, MW-801, MW-802, MW-803, and MW-804 to allow standing water to drain from the casing.

The following wells were abandoned during the field work; MW-100, MW-103, MW-104, MW-202, MW-204, MW-205, MW-206, MW-207, MW-301, MW-309, MW-310, MW-311, MW-312, MW-313, MW-500, MW-511, and MW-512. Water Well Sealing Reports, which document the closure of these wells are included in Appendix B of this report.

3.7 MONITORING WELL DEVELOPMENT

RMIES and SHARP began developing the sixteen (16) new monitoring wells on November 11, 2002. Slow recovery rates were observed in all of the new wells. During previous sampling events, RMIES technicians have observed seasonally variable recovery rates in many existing site monitoring wells. Because of these conditions, development was conducted by surging and bailing each well dry on multiple occasions. The frequency of development was dependent on the recovery rate of each well.

Development consisted of surging the wells to suspend solids followed by bailing using disposable and dedicated bailers. Prior to bailing, water levels were measured and recorded in the logbook. In-situ field parameters were measured using an YSI 556 Multi-Parameter Water Quality Meter and recorded in the logbook. Parameters included temperature, barometric pressure, conductivity, pH, oxidation/reduction potential (ORP), and dissolved oxygen (D.O.). See Table B for a listing of the amounts of water purged from these wells.

3.8 GROUNDWATER SAMPLE COLLECTION ALONG GEOPROBE® TRANSECTS

SHARP installed temporary piezometers in boreholes at locations to the depth interval in each transect where the most water was likely to be present based on observations from Macro-Core® soil samples.

Groundwater samples were collected from the temporary piezometers using a QED ¾-inch bladder pump. The pump was set at the lowest possible sample rate (~10 ml/minute) and the groundwater level was monitored with an electronic water level tape. Prior to collecting the groundwater samples, field parameters of pH, temperature, conductivity, dissolved oxygen and oxygen-reduction potential were measured and recorded in a field book.

3.9 YIELD TEST

A yield test was conducted on MW-508 on January 22, 2003. MW-508 was selected for the yield test due to the higher rate of recharge, relative to other site monitoring wells, as reported by RMIES sampling technicians.

The yield test was conducted using a QED Sample Pro MicroPurge® bladder pump and a model MP10 Controller. This pump/controller combination allows a maximum pumping rate of 0.16 gallons per minute (6 cycles per minute @ 0.026 gallons per cycle). Results from the yield test are discussed in Section 4.7.

3.10 SIDE-BY-SIDE SAMPLING TEST

Side-by-side samples were collected from MW-101, MW-402, MW-901, MW-903, MW-904, MW-905, MW-906, MW-907, MW-908, MW-909, MW-912, MW-913, and MW-915 to compare the effects (if any) on the results when using a bailer vs. when using low-flow techniques. Note MW-902 yielded sufficient water for the low-flow sample only. Low-flow groundwater samples were collected using a QED Sample Pro MicroPurge® bladder pump and a model MP10 Controller. The MP10 controller was equipped with a MP-30 Drawdown/Water Level Meter to minimize disturbance to the formation during sampling. The probe on the Drawdown/Water Level Meter was placed at a level that allowed control of drawdown to a level below the top of the well screens. Field parameters were monitored using a QED MP 20 Flow Cell and recorded in the logbook. Turbidity was measured using a Hach Model 2100P Portable Turbidity Meter (Hach) and recorded in the logbook and presented in Table 11. Samples were collected for VOCs, total and dissolved uranium, lead and barium, and Tc-99.

Following the collection of the low flow samples, each well was bailed “dry” and allowed to sufficient recovery time before bailer samples were collected. Prior to collecting the bailed samples, in-situ field parameters were measured using the YSI 556 Multi-Parameter Water Quality Meter and NTU using the Hach. Results were recorded in the logbook. A disposable bailer was then lowered until the top of the bailer was slightly below the static water level. The bailer was then removed and samples were collected for the same constituents collected using the low flow methods. At the completion of sample collection, in-situ field parameters and NTU were measured a second time for comparison purposes. Field parameters and NTU recorded during the side-by-side sample collection are summarized in Table 11.

3.11 SLUG TESTING

The Bouwer and Rice slug test was utilized for the hydraulic conductivity testing at the RMI. The “slug-out”, or “rising head” test to be used at the Site was based on quickly withdrawing a volume of water from the well and measuring the subsequent rate of rise in the water level in the well. A pressure transducer/data logger was utilized to monitor and record the rate of rise of the water level in the well. The specific procedures used are described in more detail in the standard operating procedures for conducting slug tests at the RMI Facility.

Each well was bailed so that water levels dropped by at least 40% of the total column of water in the well, based upon static conditions. The rising head test is typically logged until 90% recovery of the water level has been achieved. The rate of change in water level will decrease as the test proceeds, and in some wells, after the rate of change decreased to what was essentially a constant low rate (e.g., 0.01 ft per hour for 24 hours) the test was terminated. Therefore, the actual termination time of the slug tests at the RMI facility were either based on 90% recovery of water levels or a field decision based upon the rate of change of the water levels. Results from the slug tests are further discussed in Section 4.10 of this report. The graphical analysis of the tests and summary table and graph are contained in Appendix H.

4.0 RESULTS AND INTERPRETATIONS

4.1 GROUNDWATER POTENTIOMETRIC SURFACES

Static water levels were measured at the Site on January 3, 2003, and on May 18-20, 2003. The measured water levels were converted to elevations in the state plane coordinate system and plotted on a three base maps. Potentiometric surface maps were produced using wells completed in each of the three geologic units. Figures 4.1 and 4.1A present the potentiometric surface for the glacial till wells, Figures 4.2 and 4.2A present the potentiometric surface for the interface wells, and Figures 4.3 and 4.3A present the potentiometric surface for wells completed in bedrock.

Till:

The potentiometric surface for the Glacial Till wells (Figure 4.1) has been plotted using two-foot contour intervals. The groundwater surface elevation in MW-907, located on the southwest corner of the Site, is 634.61 feet. This represents the highest groundwater elevation in Glacial Till wells in January 2003. The well with the highest water level elevation in May 2003 is MW-906. The lowest groundwater surface elevation in January and May is 604.18 and 603.24, respectively, in MW-914, located on the northwest corner of the site. The overall configuration of groundwater flow remained the same for those measurement periods.

In general, the potentiometric surface slopes to the north in a pattern that is similar to the site ground surface elevation pattern. The slope that is portrayed generally indicates the direction of groundwater flow, which is toward Fields Brook. The potentiometric surface gradient increases in Area C, along the escarpment, reflecting the surface topography. On the southeast portion of Area B, and the south portion of Area D, the groundwater surface is relatively flat, as is the surface topography. The potentiometric surface gradient increases in Area C, along the escarpment, reflecting ground surface topography. On the southeast portion of Area B, and the south portion of Area D, the groundwater surface is relatively flat, as is the surface topography.

The gradient (slope) of the groundwater surface and the permeability derived from the Shelby tubes may be used to determine the velocity that groundwater is moving within the till section. A derivation of the Darcy Equation is used for this analysis, as follows;

$$v = 1035354 * \frac{ki}{n}$$

where:

v = average velocity of groundwater (GW), feet/year

i = gradient (slope) of GW table between two defined points in a given area, feet/feet.

k = permeability, centimeters per second

n = porosity, .30 (as previously used) unitless

1,035,354 = conversion from cm/sec to feet/year

For the FEP WMU area, the groundwater gradient in the till is 0.0048, measured between MW-501 and MW-901 (reference Figure 4.1). The averaged permeability derived from Shelby tubes

taken in till/native undisturbed material is $8.61\text{E-}07$ cm/sec. Using the equation above, the horizontal groundwater flow through the *undisturbed* till material under the FEP WMU is about 0.01 foot/year. The gradient across the main part of the site (south of the escarpment and outside of the FEP WMU) is generally lower than that used in the calculation in the FEP WMU area, and would result in a lower groundwater velocity in that area.

The velocity derived by using a hydraulic conductivity value based upon the geometric mean of slug tests from 10 wells was 0.07 ft/year (Eckenfelder, 1989). This slightly higher velocity (same order of magnitude) reflects the influence of higher permeability silt lenses in the brown till that some of the wells are screened in. Hydraulic conductivity results for a series of slug tests were also reported in the Eckenfelder report (1989). Wells MW-100, MW-101, MW-103, MW-104, MW-105 and MW-106 all have filter packs and screens that extend across from the brown till and associated silt seams. These wells have significantly higher hydraulic conductivity (10^{-5} to 10^{-6} cm/sec) than wells MW-306, MW-307, MW-314, and MW-315 that are screened only in the lower, gray till (10^{-7} to 10^{-8} cm/sec).

The amount of water that may be produced from an aquifer is normally defined as the yield of a single production or extraction well screened within the aquifer, for a sustained period (8-hours). With regard to the till underlying the RMI facility (WIDE, 1999), it has been difficult to produce enough water from some of the wells for complete development. The closest "test" that has been performed at the facility is the Demonstration of the Well Injection Depth Extraction (WIDE) soil flushing. The flow rate for **all of the PVWs in a quadrant** for a six-hour period decreased to 25 gallons per hour (0.4 gallons per minute) with a high vacuum applied and no injection. Based upon the existing information from the WIDE tests, the tills k underlying the site are not capable of producing a sustained yield in a single well of even close to 0.5 gallons per minute.

The results of the slug tests SHARP performed on the newly installed 900 series wells were analyzed to determine what the yield from those wells could be. The 20% recovery level (after baildown) was used. Using the time from the cessation of bailing (or pumping) to 20% recovery will derive a higher yield than the averaged data, as the water level recovery from a slug test is typically logarithmic in nature. Based upon this analysis, the highest yield in any of these wells was found in MW-906. MW-906 was completed in a silt unit within the till. The yield from this well was < 0.6 gallons per hour, or < 0.01 gpm. The yields from the till, interface, and bedrock wells were an order of magnitude less than those from the wells completed in the silt unit

Interface:

The potentiometric surface for the interface wells (Figures 4.2 and 4.2a) has been plotted for January and May 2003 in two-foot contour intervals. Six wells were used to produce the maps. All six wells are located at the top of the escarpment in the vicinity of the FEP WMU. In general, the potentiometric surface slopes to the north with a channel-like drainage pattern beneath the FEP WMU. These maps are controlled by levels in well MW-902. Potentiometric measurements collected seasonally will help determine whether this changes over time.

Bedrock:

The potentiometric surfaces for the bedrock wells (Figures 4.3 and 4.3a) have been plotted in one-foot contour intervals. We question the groundwater elevation data for MW-405 and MW-

200. MW-200 has a groundwater elevation significantly higher than all other bedrock wells for both measurement periods— potentially due to a compromised completion, and so this data point was not included on the potentiometric surface map. MW-200 was completed as a single cased well with only a grout seal from the surface into bedrock. MW-405 is located within 10-feet of MW-404 and is screened at the same depth interval; however in January 2003 the static water elevation is 4.51-feet greater in MW-405. Well MW-402 was used. This well is completed with a double casing so that the well is sealed into the top of bedrock with a steel casing, as well as the grout between the outer casing and the riser. It is unlikely that this difference is representative of the actual potentiometric surface. The groundwater elevation in MW-405 is shown on the map but was not used in the contours. When water levels were taken in May well MW-405 was not accessible because of deep standing water around the well. Water level elevations from January and May 2003 from the bedrock indicate that over most of the site, the gradient in the shale is very low, with flow to the northeast.

The newly installed monitoring well MW-900 is double cased, with the outer casing grouted into the top of bedrock.

4.2 TCE CONCENTRATIONS IN SOIL TRANSECTS

A discussion of the analytical results in transects where TCE was detected follows (see Figures 3.1 through 3.10 for the individual transects and Figures 6.1 and 6.3). Concentration data are provided on these figures as well as in Tables 7 and 9. TCE data collected from temporary piezometers may differ somewhat from data collected in the same vicinity using a typically constructed monitoring well.

Transect #1:

TCE is present at concentrations ranging from 4.25 ug/kg to 112,000 ug/kg in the A and B borings in Transect #1. Both borings are located north of the trench and are within the FEP WMU. TCE was detected at a concentration of 112,000 ug/kg in the sample collected at 14-feet in boring A. This sample was collected from an area where fractures are present in the till and is the only sample location (out of all the soil samples collected from these transects) where the TCE concentration exceeds the soil cleanup criteria of 22,600 ug/kg. TCE is also present at the base of the surface fill at a concentration of 4.25 ug/kg (2.9-feet) and at 4,200 ug/kg in a fractured zone at 6.5-feet. TCE was present at 27.8 µg/L in the *groundwater* sample collected from boring B. The screened interval was set from 3-feet to 8-feet; however the only water observed in this boring was perched at the base of the fill material from 2.3-feet to 2.9-feet. Groundwater was not present below the surface fill in any of the borings installed in Transect #1. Both groundwater and soils are TCE-contaminated above standards.

Transect #2:

TCE was detected in three soil samples collected from borings installed in Transect #2. At the base of the fill material, TCE was present at concentrations of 4.83 ug/kg and 1.27 ug/kg in borings B and D, respectively. TCE was detected at a concentration of 212 ug/kg in boring B at 6.5-feet. This sample was collected from a saturated silt lens. The groundwater sample collected from a piezometer screened in this silt lens contained TCE at a concentration of 230 µg/L. TCE contamination is present above standards in the groundwater but not the soil.

Transect #3:

TCE was detected in five soil samples collected from borings installed in Transect #3. Two of these samples were collected from the native soil encountered directly beneath the surface fill and concentrations are significantly below cleanup criteria. Three samples with detectable concentrations of TCE were collected from a saturated silt lens. The highest TCE concentration from the samples collected from the silt lens is 114 ug/kg in boring F at 6.5-feet. This concentration is significantly below the soil cleanup criterion. TCE was not detected in the groundwater sample collected from this transect.

Transect #4:

TCE was not detected in the any soil samples collected from borings installed in this transect. TCE was not detected in the groundwater sample collected from this transect.

Transect #5:

TCE was detected in 5 soil samples collected from borings installed in this transect. Two of these samples were collected from the native soil encountered directly beneath the surface fill and concentrations are significantly below cleanup criteria. Three of the samples with detectable concentrations were collected from the soil located directly beneath a saturated silt lens. Concentrations of TCE beneath the saturated section ranged from 56.9 ug/kg in boring D at 7-feet to 739 ug/kg in boring E at 7.5-feet. TCE was not detected above the cleanup criterion in any soil samples collected from this transect.

TCE is present at a concentration of 12.8 µg/L in the groundwater sample collected from boring D. Groundwater was present in this boring in the silt lens from 4.1-feet to 9-feet. The outfall line in the vicinity of Transect 5 is present at more than 12 feet deep. Thus, unless the groundwater flows upward from the utility line (possible at certain times of the year) the shallower groundwater is unlikely to have become contaminated by the deeper utility line. Transect 5 is located near visible surface water drainage ways that may have allowed TCE deposition (from spills or airborne deposition) that percolated through the more permeable zones noted in the this transect.

Transect #6:

TCE was detected in one soil sample collected in Transect #6. Boring A contained TCE at a concentration of 1.57 ug/kg in the sample collected at 12.5-feet. Fill material extended to 11.0-feet at this location. Due to the absence of any groundwater in this transect a temporary piezometer was not installed.

Transect #7:

TCE was detected in four samples collected from boreholes in Transect #7. The highest concentration is 4.68 ug/kg in boring F at 5.0-feet. This represents the soil at the base of the saturated silt located from 4.1-feet to 5.2-feet. TCE was not detected in the groundwater sample collected from transect #7.

Transect #8:

TCE was not detected in the any soil samples collected from borings installed Transect #8. TCE was not detected in the groundwater sample collected from this transect.

Transect #9:

TCE was not detected in the any soil samples collected from borings installed in Transect #9. TCE was not detected in the groundwater sample collected from this transect.

4.3 TCE CONCENTRATIONS IN MONITORING WELLS

TCE data from the most recent groundwater samples from monitoring wells are presented in Figures 4.4-4.6. These data include August 2001, September 2002 and May 2003 sample events. Results prior to August 2001 that were used are indicated on the figure along with the sample date. Note that all the new 900 series wells were non detect for TCE with the exception of MW-903 which was 0.478 ug/L. The TCE delineated plume is limited to the FEP WMU area.

TCE is present in groundwater at levels above its MCL principally in the FEP WMU. Figure 4.4 shows isoconcentrations as high as 475,000 µg/L in till wells and is limited to the FEP WMU. However, MW 502 (located ~40' from the zone of maximum TCE concentration) has TCE at only 1,190 µg/L. This heterogeneity is consistent with the site conceptual model that show that groundwater migration of TCE (and other soluble constituents) occurs at a significant rate only through more permeable zones; i.e., the TCE has been present at the site for decades but has not migrated even 40 feet using a typical groundwater plume migration mechanism.

MW-206 (in lower Area C) has a TCE detection of 6.49 µg/L. With the non-detects in wells located at the top of the escarpment (MW-306 and MW-307) and the site conceptual model that shows very slow migration in the absence of conduits, the TCE in MW-206 is potentially the result of seep/surface-water-associated transport of TCE down the escarpment to the Lower Area C and percolation into the subsurface.

TCE has been detected in bedrock MW-200 historically above the clean-up standard (MCL), 738 ug/L in 2000. However, as noted in Section 4.1 above, MW-200 was installed as a singled cased well through a highly contaminated till layer (next to abandoned MW 104 with a TCE groundwater concentration around 140,000 ug/L). It is more likely that the TCE contamination in MW-200 is due to transport from the till layer due to MW construction, rather than general plume migration through bedrock. By contrast, the newly installed monitoring well MW-900 is double cased, with the outer casing grouted into the top of bedrock. MW-900 did not produce sufficient groundwater to complete sampling for this report.

Interface MWs 309, 310 and 311, which were abandoned during this investigation due to compromised integrity, historically indicated TCE contamination levels above the MCL. However, as these wells were also not double cased through the contaminated till zone, the apparent contamination is more likely due to well construction than naturally occurring plume migration.

Figure 4.5 presents the TCE concentrations in the Interface unit. MW-902 resulted in a non-detect. Figure 4.6 presents TCE concentrations in the Shale unit wells.

One groundwater sample collected during the transect study that has a TCE concentration above its MCL is located at a depth of 3-8 feet in the FEP WMU (at Boring 1B). The only water

sample from a temporary piezometer that has a TCE concentration (of 12.8 µg/L) that exceeds its MCL (of 5 µg/L) is located at a depth of 5 – 11 feet in Boring 5D. Figure 3.5 shows that the sample was collected from a more-permeable zone in Transect 5.

4.4 TOTAL U / Tc-99 CONCENTRATIONS IN SOIL TRANSECTS

The Total U and Tc-99 *soil* concentration results are summarized on Figure 6.2 and on Figures 3.1-3.10. Thirty of the 120 Total U results from the SHARP samples exceed the 43 mg/kg soil standard; however, only one of these detections (BH8B) is from a sample located at a depth greater than 5 feet.

Note the Tc-99 data used to prepare maps and tables in this report contains concentrations with negative values and a non-detect (“U”) qualifier. These data were obtained from the laboratory electronic deliverable (EDD) as a direct data transfer from the laboratory information system (LIMS) and concentrations reported as negative values and non-detect are not unusual in radiochemistry analyses and are considered non-detect and less than the minimum detectable activity (MDA).

Uranium in groundwater exceeds the standard in Transect 3, Transect 5, and Transect 8 (see Figure 6.3). Transect 8 has uranium in soil at depth; Transect 5 has more permeable sections and TCE results that exceed its MCL. The Transect 3 water result is not as clearly correlated with the soil contamination or geology noted above for Transects 8 and 5. However, false positive results associated with turbid samples may occur when sampling from temporary piezometers.

Tc-99 in soil exceeds its standard in one location only (Transect 1) at a depth of 3.2’ and only by a small amount (value of 65.1 pCi/g vs. the 65 pCi/g standard). One Tc-99 groundwater result exceeds the standard: Transect 2 (within the FEP WMU) at 4-9’.

Concentration data for Uranium and Tc-99 are provided in Table 8.

4.5 TOTAL U /TC-99 CONCENTRATIONS IN MONITORING WELLS

Figures 4.7 through 4.9 present the total U concentrations in monitoring wells for the till, interface and shale aquifers, respectively. Total U is present above the cleanup standard in wells in the vicinity of the FEP WMU. The highest concentrations are in MW-503 at 7510 ug/L. The new wells MW-901 and MW-903 were installed to complete the delineation of the northern and eastern edge of the plume.

Based on historical MW data, the total U plume appears to be limited to the till unit. Uranium concentrations within MW-200 are below the site’s cleanup standard. However, Uranium concentrations in abandoned interface MWs 309, 310 and 311 exceed the cleanup standard, based on historical sample data, although again this may be attributed to MW construction.

Total U is not present above the cleanup standard in MWs outside of the vicinity of the FEP WMU. This is in contrast with historical MW data that indicates that Uranium contaminated

groundwater is also located outside the FEP WMU in MWs 101, and abandoned MW 103 and 512 (see also the Sharp & Associates Report for the Phase 1 Groundwater Investigation at the RMI Extrusion Plant Site). However, the following observations should be noted:

1. MW 103 and 512 were abandoned due to damage during the Phase 2 Groundwater Investigation. Additionally, the bentonite seal for MW-103 was installed close to the surface, above the frost line. It is suspected that these MWs may have provided pathways for surface contamination due to suspect integrity. These MWs were replaced by new MWs 909 and 913. Initial sample results for these wells indicate that the Uranium contamination in groundwater is within the site cleanup standard (see Table 10). Additional sampling is recommended to confirm this initial assessment.
2. MW-101 is located beneath the ESH Modular Office and was installed prior to installation of the building. The bentonite seal for the well is located near the surface. The soil in the vicinity of the ESH Modular Office was contaminated with Uranium in excess of the site soil cleanup standard, but was remediated (excavated) in December, 1990 to the existing soil cleanup standard for the site. Historic groundwater data for MW-101 indicated Uranium contamination above the site cleanup standard. From 1985 to 1997 Uranium concentrations in groundwater averaged 62 ug/L with a maximum value of 331 ug/L recorded in 1996. Since 1997, the average Uranium concentration was 26 ug/L with a maximum value of 28 ug/L. The most recent sample results, using low flow sampling and bail-sampling methods were 14 ug/L (during this investigation). It is suspected that the earlier, higher contamination levels resulted from transport of surface or near surface contamination through the shallow MW seal.

Figures 4.10 through 4.12 present the Tc-99 concentrations in monitoring wells for the till, interface and shale aquifers, respectively. The Tc-99 footprint is similar to total U and limited to the till unit. The peak concentration is in MW-501 at 224,000 pCi/L.

4.6 SIDE-BY-SIDE SAMPLE RESULTS

Table 11A presents the completed results of samples collected "side-by-side" using different techniques. Results from MW-101 show little difference in results irrespective of how the sample was collected or whether the sample was filtered. The results for MW-101 are apparently representative of actual groundwater conditions. Similarly, the results for MW-906 differ only slightly irrespective of the sampling method. However, the results from the MW-905 samples illustrate how sampling method can have an effect on results. The unfiltered bailed sample had concentrations of lead nearly an order of magnitude higher than the filtered sample. Barium concentrations in the unfiltered sample were ~3x that of the filtered sample. The low-flow samples (whether filtered or unfiltered) are much closer to the results of the bailed/filtered sample. The detections of lead and barium in the unfiltered bailed sample are false positives associated with suspended sediments; constituents present in sediments are falsely reported as being associated with groundwater.

Observations of the side-by-side sample data are as follows:

- All lead sample results are below the groundwater cleanup goal of 15 µg/L (highest concentration at 13.6 µg/L in well MW-903).
- All barium sample results are below the groundwater cleanup goal of 2000 µg/L.
- All Tc-99 results for these wells were non-detect.
- The barium in MW-402 was 61.5 µg/L for low-flow/unfiltered; the bailed/unfiltered result for this well was 417 µg/L. Wells such as MW-904, MW-905, MW-908, MW-912, and MW-913 all have results that the bailed/unfiltered result was higher in barium concentrations than the low-flow/unfiltered result. This indicates that the barium was more likely from the soil rather than from the groundwater.
- Uranium results were all below the cleanup goal with the exception of well MW-901 which is located within the FEP WMU area.
- Turbidity levels gradually decreased during sample collection when samples were collected using the low flow method and increased significantly during sample collection when using the bailer method.
- There is significantly less variability in field parameters in samples collected using the low flow method when compared to samples collected using the bailer method.

In general, the four samples (bailed/filtered, bailed/unfiltered, low-flow/filtered, and low-flow/unfiltered) taken at each of the wells were similar in concentrations when compared with their respective results.

4.7 YIELD TEST RESULTS

A yield test was performed on Monitoring Well MW-508 by utilizing a low flow sampling pump to draw down the water level in the well. Due to single digit temperature conditions, the discharge hose froze during the test, resulting in an incomplete data set. The test was conducted for a period of less than 10 minutes prior to the discharge hose freezing. However, during this period, the pump rate varied from 0.156 gallons per minute at the start of the test to 0.026 gallons per minute just prior to the line freezing. The drawdown just prior to the line freezing was 3.31 feet and had not stabilized. Therefore, the estimated yield from this monitoring well is < .026 gpm.

As described in Section 4.1 of this report, another test of groundwater yield was the operation of the WIDE system. The maximum sustained yield of the wick drains (35 drains, 15' deep in a 35' X 35' grid) was 25 gallons per hour (0.417 gpm), or less than 0.01 gpm per drain. This testing supports the statement that the yield of the glacial till at the Site is below 0.50 gpm.

4.8 RESULTS FROM "SEEP/SURFACE WATER" SAMPLE

As noted above, RMIES collected what they identified as a "seep/surface water" runoff sample on November 6, 2002 from the vicinity of the seeps located at the top of the escarpment with the following results: Total Uranium: 681 µg/L and TCE: 1.98 µg/L. RMIES also collected a seep/surface water runoff sample at a location ~halfway down the swale with the following results: Total Uranium: 565 µg/L and TCE: none detected.

There were site rain events on May 21 and 27, 2003 yielding 0.32 and 0.53 inches of precipitation. During the site visits the day following each of these rain events, SHARP field personnel estimated that greater than 90 % of the water was coming from surface water runoff from Area 1, the ditch in the FEP WMU, and Area 2, the low lying areas east of the ditch but in the same general area of the FEP WMU. Area 3 was a smaller area further to the east, adjacent to the FEP WMU area and off the corner of the soil staging pad where there was seepage observed from the sloping surface. These areas are identified on Figure 3.11, and the surface flow is to flags 3 and 4. At the time the escarpment was examined it could not be determined if there were additional seeps that contributed to the volume of flow at flags 1 and 2, as these were covered with surface flow from further up the escarpment. A water sample was collected at flagged location 4, and consisted of water that had consolidated from the 3 areas described. The water sample from Flag location #4 contained 58.8 ug/L of U and was non detect for TCE.

These results indicate some potential for surface-water-associated sediments to migrate from the top of the escarpment. It is unclear whether this level of migration will unacceptably re-contaminate the Lower Area C. The low levels of TCE may evaporate with the surface water. However, if the water is allowed to stand in the lower Area C, it may percolate into the subsurface before evaporating.

Once the water evaporates or percolates into the soil, any Uranium present in the sediments will be deposited (or attenuated) in the near-surface soils, but at levels that are unlikely to be detectable in soils in the short term.

4.9 NITRATE AND NITRITE IN GROUNDWATER RESULTS

Historical and current groundwater concentrations of Nitrate and Nitrite (or Nitrates) at the site were reviewed and found to exceed the EPA Drinking Water MCL in the Groundwater Plume associated with the FEP WMU. Nitrate and nitrite concentrations are the likely result of historic discharges of neutralized and reduced nitric acid to the FEP; by the same process which also resulted in the release of TCE, Uranium and Tc-99 COCs.

Drinking Water standards for Nitrate/Nitrite were promulgated in 1992 (Source: USEPA Ground Water & Drinking Water website). Consequently, Nitrates were not identified as a COC during the RFI/Hydrogeologic Investigation for the site completed by Eckenfelder, Inc. The current MCL's for Nitrate's are: Nitrate-10 mg/L, Nitrite-1 mg/L, and Total Nitrate/Nitrite-10 mg/L.

The USEPA Technical Fact Sheet for Nitrates identifies the compounds as highly soluble with weak retention to soil, moving at approximately the same rate as water. Nitrates do not volatilize and are likely to remain in water until consumed by plants or other organisms. Nitrate degradation is fastest in anaerobic conditions. Due to these properties, Nitrate groundwater concentrations may provide a good marker for the maximum extent of the Groundwater Plume associated with the FEP WMU.

Nitrate concentrations were initially analyzed by Eckenfelder to evaluate the overall chemical quality of groundwater at the site. Initial sampling was completed from 1985 thru 1988 and included Monitoring Wells 100 thru 106, 200 thru 210, 300 thru 315 and 401 thru 403. Subsequent monitoring for Nitrate and Nitrite was also included by Safety and Ecology, Inc.

(SEC) in 2002 to evaluate progress of bioremediation associated with injection of Hydrogen Release Compound (HRC®). MWs sampled included 104, 307, 501 thru 505, 507, 508 and 803. Samples for both campaigns were collected using bailers.

Nitrate data for both sampling campaigns were grouped for evaluation, as follows:

1. Eckenfelder data was segregated by MW location (i.e. within the FEP WMU source area, downstream of the FEP WMU, Fields Brook flood plain and background, relative to the FEP WMU locations. Data was also segregated by screen interval within each location (till, interface and shale). Sample results with matrix interferences or data outliers from the Eckenfelder data set were not included.
2. SEC data was also segregated for locations within the FEP WMU and downstream of the FEP. All MWs sampled were screened in the till. MWs 104 and 307 were the only two MWs common to both sampling campaigns.

Nitrate concentrations in wells located in the FEP WMU (from September 2002 SEC sampling) are detailed in Figures 4-13 and 4-14. These concentrations are similar in distribution to TCE concentrations – being located in more-permeable strata in the FEP WMU. The overall averages for MWs segregated by location and screen interval (for both Eckenfelder and SEC sampling) is also summarized in the table below:

TABLE – NITRATE GROUNDWATER CONCENTRATIONS (mg/L)				
	1985-1988		2002	
MW LOCATION/CONFINING LAYER	AVG.	MAX.	AVG.	MAX.
Within FEPA WMU:				
Till	3753.9	6530	1911	7800
Interface	38.6	289	NS	NS
Shale	75.4	230	NS	NS
Downstream of FEPA WMU:				
Till	9.1	80.7	0.34	0.89
Interface	1.58	8.2	NS	NS
Shale	NS	NS	NS	NS
Fields Brook Floodplain:				
Till	1.1	2.6	NS	NS
Interface	NS	NS	NS	NS
Shale	NS	NS	NS	NS
Background MWs:				
Till	0.69	2.43	NS	NS
Interface	ND	ND	NS	NS
Shale	ND	ND	NS	NS

Notes: A summary of all MWs and data reviewed is included in Table 13 of this groundwater investigation report.

NS – Not sampled.

ND – Not detected.

(SEC) in 2002 to evaluate progress of bioremediation associated with injection of Hydrogen Release Compound (HRC®). MWs sampled included 104, 307, 501 thru 505, 507, 508 and 803. SEC Samples for both campaigns were collected using bailers.

Nitrate data for both sampling campaigns were grouped for evaluation, as follows:

1. Eckenfelder data was segregated by MW location (i.e. within the FEP WMU source area, downstream of the FEP WMU, Fields Brook flood plain and background, relative to the FEP WMU locations. Data was also segregated by screen interval within each location (till, interface and shale). Sample results with matrix interferences or data outliers from the Eckenfelder data set were not included.
2. SEC data was also segregated for locations within the FEP WMU and downstream of the FEP. All MWs sampled were screened in the till. MWs 104 and 307 were the only two MWs common to both sampling campaigns.

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Interface	38.6	289	NS	NS
Shale	75.4	230	NS	NS
Downstream of FEPA WMU:				
Till	9.1	80.7	0.34	0.89
Interface	1.58	8.2	NS	NS
Shale	NS	NS	NS	NS
Fields Brook Floodplain:				
Till	1.1	2.6	NS	NS
Interface	NS	NS	NS	NS
Shale	NS	NS	NS	NS
Background MWs:				
Till	0.69	2.43	NS	NS
Interface	ND	ND	NS	NS
Shale	ND	ND	NS	NS

Notes: A summary of all MWs and data reviewed is included in Table 13 of this groundwater investigation report.

NS – Not sampled.

ND – Not detected.

The MW sample populations for the two referenced campaigns included different MWs due to new MW installation/abandonment and different sample objectives. A comparison of the Nitrate data for both campaigns allows some observations listed below.

1. Nitrate concentrations, both historical and present, are significantly higher in the Groundwater Plume associated with the FEP WMU, than for other areas of the site. There was little, if any Nitrate contamination in background MWs and MWs located in the Fields Brook Flood Plain based on the 1985-88 results. This confirms the former evaporation pond as the most likely source of the Nitrate groundwater contamination.
2. Concentrations of Nitrite also exceed the MCL (1.0 mg/L) within the FEP, with an average value of 5.6 mg/L and a maximum value of 39 mg/L (MW 505, 2002). Downstream MWs averaged 0.02 mg/L, with a maximum value of 0.16 mg/L.
3. The Nitrate concentrations have not appreciably changed in the fifteen years between sampling campaigns, although some degradation may have occurred. For MW 104, Nitrate concentrations averaged 1955 mg/L (1985-1988), with a maximum value of 6530 mg/L. In 2002, the average value was 1560 mg/L, with a maximum value of 1590 mg/L. For MW 307, the Nitrate concentration averaged 2.2 mg/L ('85-88) vs. 0.1 in 2002.
4. Although there appears to be some migration of Nitrate to downstream MWs, this probably represents the maximum extent of the groundwater plume to date. Two (2) exceptions this observation are MWs 209 and 206, in which Nitrate concentrations averaged 26 and 71 mg/L during the 1985-88 campaign (see Table 13). Excluding these MWs, the average Nitrate concentration (for the 85-88 samples) was 1.0 mg/L. Since this sampling campaign, both MWs were abandoned due to compromised integrity of the MWs.
5. Some vertical migration of Nitrates for MWs within the FEPA WMU is apparent. Interface MWs located within the FEPA WMU averaged 38.6 mg/L. The average concentration for MW 200 (screened in the shale) was 78.4 mg/L; although this value may reflect contaminant migration due to MW integrity.

Nitrates are typically a good marker for water migration from the nitrate source. However, because surface water or seep migration at the site, as noted elsewhere in this report, may confound the picture, the nitrate concentration distribution provides only a general view of historic groundwater migration. SHARP recommends that sampling of MWs downgradient of the FEP, including 509, 510, 900-902, 912, and 914 be sampled by RMIES, using low flow sampling techniques, to further evaluate the extent of Nitrate/Nitrite contamination.

Analysis by SEC and others indicate that deposited nitrate or nitrite may interfere with HRC reduction of TCE. The likely mechanism of interference is reduction of nitrate to nitrite in preference to reductive dechlorination of TCE. If this were occurring to a great extent, one would expect to see increasing levels of nitrite and decreasing levels of nitrate. This has not yet been observed. However, as previously noted, degradation of Nitrates should be accelerated under anaerobic or reducing conditions. Injection of HRC may provide a remedial strategy for

Nitrate contamination. Ex-situ treatment technologies for Nitrates include ion exchange and reverse osmosis.

4.10 COMPARISON OF BAIL-DOWN (SLUG) AND SHELBY TUBE TEST RESULTS

Table 2 presents a summary of the slug and Shelby tube tests at the site. Figure 4.14A presents these data graphically. The results are grouped by lithology. The graphs and analyses of the slug tests are contained in Appendix H. Appendix H also contains a summary table and a summary graph of the results, and are also discussed by lithology below.

Fill

Monitoring well MW-910 is completed in fill material that was described in the well log as gray silty clay. The well was very slow to recover from development and so could not be slug tested. An analysis of the recovery data after bailing for development indicates that the Hydraulic Conductivity is less than $5\text{E-}08$ cm/sec. There were 6 Shelby tubes from 3 wells analyzed. The Shelby tube from MW-910 that was taken from 5 to 7 feet corresponds very well with the slug test (screened interval from 7.5 to 9.5 feet). The other Shelby tube analyses show a wide range of values within the fill.

Silt

MW-903, MW-905, and MW-912 are completed in the till with some silt present in the screened interval. MW-906 is completed in the till, and the screened interval may have some connection to the overlying silt through fractures. The hydraulic conductivity of the silts influenced the results of these tests and these were the highest conductivities seen in any of the wells that were slug tested. The values ranged from $3.6\text{E-}07$ to $9.4\text{E-}06$ cm/sec.

Till with Fractures Present

MW-908 and MW-907 were completed in the till but fractures were identified within the completion interval. The hydraulic conductivities derived from the slug tests are intermediate between the higher values in the silt and the lower values seen in the gray till without fracturing.

Gray Till

The Hydraulic Conductivity values derived from the slug tests of all of the wells completed in the Till range from $1.8\text{E-}07$ to $8.7\text{E-}07$, with the exception of MW-914. MW-914 was very slow to recover from development and so could not be slug tested. An analysis of the recovery data after bailing for development indicates that the Hydraulic Conductivity in the till at this location is less than $7\text{E-}08$ cm/sec.

Interface

MW-902 was screened across from the interface between the unweathered gray till and bedrock. The recovery from development was very slow and so the well could not be slug tested. However an analysis of the recovery data from development indicates that the Hydraulic Conductivity is less than $3\text{E-}08$ cm/sec.

Bedrock

MW-900 is completed within bedrock. The recovery from development was very slow. The analysis of recovery data from development indicates that the hydraulic conductivity of the bedrock interval that this well is screened across from is less than $4\text{E-}08$ cm/sec.

5.0 CONTAMINANT FATE AND TRANSPORT

Based on its review of historic and recent site data, SHARP has determined that:

- *Site groundwater is typically present in very-low-permeability matrices*; contaminant transport within these matrices is slow; thus, contaminant transport beyond the source areas typically occurs via more-permeable conduits. Identification of the degree that the effluent line that traverses the site (and the roof drains of the Main Plant that empty into the drain) may have acted as a constituent conduit was one of the goals of the Phase II investigation.
- *Several wells were* buried, contaminated with grout, affected by frost heave, screened close to the surface, or otherwise *compromised*. In addition, many site wells have well screens that span more than one matrix – potentially allowing contaminants present in one horizon to be mis-attributed to another. Compromised/damaged wells were repaired or replaced as necessary.
- *False-positive “hits”* above cleanup standards in many site wells may have resulted from compromised well completions and a sampling technique that may not always provide samples that are representative of groundwater conditions.

The determinations listed above combine to show that *found contamination in soil or groundwater does not typically travel far from site source areas under most conditions* and even this transport does not occur via conventional groundwater transport mechanisms (that assume a homogenous hydraulic conductivity). These findings have several implications concerning the eventual cleanup of the site and the potential applications of risk-based strategies.

5.1 SITE CONSTITUENTS OF CONCERN / MIGRATION MECHANISMS

The primary CoCs detected at the Site include RCRA parameters (primarily TCE) and radiological parameters Total U and Tc-99. Their presence above cleanup standards in site media must be addressed prior to site closure.

Uranium is naturally-occurring in northern Ohio soils but its detection in soil and groundwater at levels that exceed the cleanup standard for the Site is attributable to historic RMI Site operations. Uranium oxides are typically particulate-associated. Historic Site operations produced uranium fumes (fine particulates) that were transported in air over short distances from the source and then deposited on Site surfaces (including surface soils) over the years. These particulates may have been transported with other suspended solids in surface water. Due to typically low solubility, the presence of uranium in groundwater far from a uranium source is unlikely.

Because uranium is an element, its mass is conserved. Natural attenuation mechanisms are limited to retardation processes.

Tc-99 does not have a natural source; it is a by-product of the nuclear industry. Its presence at the RMI Site is attributed to past operations associated with processing of uranium. It was also deposited at the site as a fine particulate. Oxides of Tc-99 are slightly soluble in water; thus, the

detection of Tc-99 at a distance from its source can result from transport via sediments, or less likely via dissolution and migration with groundwater.

Because Tc-99 is an element, its mass is conserved. Natural attenuation mechanisms are limited to retardation processes.

TCE does not have a natural source. Its presence is entirely associated with historic RMI Site operations or contamination associated with the Fields Brook Superfund Site. TCE is a dense, non-aqueous-phase liquid (DNAPL) at ambient conditions with a significant water solubility of greater than 1,500,000 µg/L. It can be transported in groundwater in the liquid or dissolved phase. There is some potential for transport with surface water sediments; however, transport with sediments is expected to be a minor mechanism compared to transport as the free liquid or dissolved in water. Given that all detected concentrations of TCE in groundwater are less than 1,500,000 µg/L and concentrations of TCE are higher nearer the surface, there is no need to infer the presence of *substantial* free-phase TCE as a DNAPL layer beneath the Site to account for the Site TCE. TCE sources resulted from two types of activities:

- The placement of liquid phase TCE onto site surface soils (like into the FEP WMU area) – allowing percolation of free-phase TCE and dissolved-phase TCE into the groundwater; and
- The deposition of airborne TCE exhausted from Site operations by the action of rainwater. Thus, roof-drain or other rainwater may be an alternative source of site TCE. Most TCE deposition by rainwater onto uncontaminated media (surface soil) is not present at a high enough concentration to be detected; however, this mechanism could account for ppb concentrations in roof drain water.

In addition to retardation processes, TCE will also be attenuated in the environment by biodegradation and volatilization processes. In the absence of non-chlorinated substrates [or other electron donors (e.g., HRC) that generate reducing conditions] the biodegradation of TCE is very slow.

Distribution Coefficients (Kd) are often used to describe how constituents will partition among two different phases. They describe the ratio of “equilibrium” concentrations in each phase. Although Kds can be effectively determined in a laboratory for distribution that occurs between two different *liquid* phases, their use to describe distribution between groundwater and the groundwater unit matrix cannot be reliably determined in the laboratory because these values are affected by changes in both groundwater chemistry and matrix composition. In addition, even if Kds are derived empirically using actual Site groundwater and actual Site matrix measurements, their values can be affected dramatically by changes to pH, oxidation-reduction potential, constituent oxidation state, etc. Finally, Kds describe only *equilibrium* conditions; in the environment, kinetic factors may make the Kd values useless as a predictive tool because equilibrium may never be attained under actual Site conditions.

Relative Distribution Coefficients: For groundwater conditions prevalent at the Site, TCE is much more soluble than Tc-99 containing species which are more soluble in water than uranium-containing species. Transport at the Site can be model calibrated by evaluating the relative migration of these constituents. Where constituent transport is occurring according to dissolved-

phase *groundwater* movement, the leading edge of the TCE plume would appear ahead of the leading edge of the Tc-99 plume; and the uranium plume would have the smallest areal extent.

5.2 SITE CLEANUP STANDARDS

The currently-established Site cleanup standards are listed below. These may be adjustable depending upon the results of a site-specific risk-based evaluation (See Section 5.3)

Radiological Parameters in Groundwater:

The in-place Site Decommissioning Management Plan was initially submitted in December 1991 and eventually approved by the NRC prior to Ohio becoming an agreement state. The current radioactive license issued by ODH (dated Aug 21, 2000) has unrestricted release *groundwater* cleanup criteria listed as 30 pCi/L Total U and 900 pCi/L of Tc-99. At the direction of RMI, SHARP used *30 µg/L for the uranium cleanup standard and 900 pCi/L for the Tc-99* cleanup standards to allow unrestricted future use of the Site under the approved plan.

Radiological Parameters in Soil:

Per the decommissioning plan, the soil cleanup standards are *30 pCi/g for uranium and 65 pCi/g for Tc-99*. The specific activity of 30 pCi/g equals *43 mg/kg of uranium*. ((~0.7 pCi/g-ppm for naturally occurring uranium).

The cleanup standards (in soil only) are *targets* (per the NRC implementation policy). Areas of residual activity exceeding the guideline value (but less than 3x the guideline value) may be allowed to remain on site provided that they do not exceed the guideline value by greater than a factor of $(100/A)^{1/2}$ where A = area of the exceedance in m². Thus, for example, as much as 129 mg/kg of uranium may be left on a small portion of the Site and still meet the soil criterion.

Residual uranium/Tc-99 concentrations in both soils and groundwater must also meet the unity rule, e.g., the sum of the ratios of the constituents to their cleanup standard must be less than 1.

$$\text{Example (for groundwater): } \frac{[\text{U in } \mu\text{g/L}]}{30 \mu\text{g/L}} + \frac{[\text{Tc-99 in pCi/L}]}{900 \text{ pCi/L}} < 1$$

TCE in Soil, OhioEPA RCRA Generic Cleanup Number GCNs:

The current RCRA permit identifies a TCE in soil cleanup standard of 22.6 mg/kg. This value is identical to the GCN for TCE in soil in the absence of a groundwater pathway. GCNs are typically used as single-chemical screening standards, usually adjusted to account for additivity of different chemicals to ensure that the site-wide risk across all exposure pathways does not exceed 1.0×10^{-5} cancer risk or 1.0 hazard index. The TCE GCNs are:

TCE soil: 22.6 mg/kg (single chemical, no groundwater)
 0.02 – 0.399 mg/kg (single chemical, protective of groundwater)

SHARP used 22.6 mg/kg for the provisional cleanup standard to be consistent with historic RMIES practices and the value present in their RCRA permit. OhioEPA RCRA has often required adjustment to the GCNs (at other sites) when using them as cleanup standards.

TCE Cleanup Level in Groundwater:

TCE in GW = 5 µg/L (equal to the USEPA drinking water standard maximum contaminant level [MCL]).

Other Potentially-Applicable Groundwater Cleanup Standards:

Other potential CoCs in groundwater that are related to historic Site operations include lead, barium, nitrate, and nitrite. The MCLs for these constituents are:

Nitrate (as N): 10,000 µg/L

Nitrite (as N): 1,000 µg/L

Lead (at tap): 15 µg/L mg/L (action level); OhioEPA GCN of 5 µg/L

Barium: 2,000 µg/L

OhioEPA has updated the CGN for lead in groundwater to 5 µg/L with site-specific evaluations allowing cleanup levels as high as the MCL of 15 µg/L.

5.3 GROUNDWATER USE IN THE VICINITY

SHARP evaluated the regional groundwater use (See Appendix E). The RMI Plant site is located in Ashtabula Township, immediately east of the City of Ashtabula, approximately one mile south of Lake Erie and immediately south of Fields Brook. Lake Erie acts as the primary drinking water source for the area. Well locations shown on Map 3, Appendix E show that there are no reported groundwater wells located within at least a one mile radius of the RMI site; and the testing and production records for the located wells show that the potential for groundwater usage is low owing to poor production, questionable water quality, and discontinuous occurrence of the shallow groundwater units.

5.4 RISK-BASED CHANGES TO CLEANUP STANDARDS

RCRA Parameters:

RCRA guidance allows site-specific risk-assessment at sites like RMI where not all exposure pathways are completed. This may allow higher cleanup standards than those presented above. However, OhioEPA has NOT historically accepted limitations on exposure pathways in the absence of a site-specific risk assessment (and they may not accept them even within the context of a risk assessment).

Potential Risk-Based Cleanup Standards, Soil:

SHARP has not performed any risk-based calculations to determine what potential cleanup standards may be successfully negotiated. However, SHARP believes that OhioEPA will not accept a TCE-in-soil cleanup standard greater than the 22.6 mg/kg standard listed in the RCRA permit. In fact, OhioEPA may require RMIES to adjust that value for the presence of other RCRA parameters or for the potential for TCE to leach to groundwater.

Potential Risk-Based Cleanup Standards, Groundwater:

There is *some* potential for increasing the cleanup standard for TCE in groundwater above the MCL of 5 µg/L. USEPA drinking water standard Maximum Contaminant Level (*MCLs*) are

extremely conservative standards when applied to this site because there are no *current* shallow-groundwater users in the area; and this groundwater will *never* yield enough water to provide a potable source for future groundwater users. A documentation of the lack of a completed pathway may allow TCE in shallow groundwater to exceed the MCL.

If OhioEPA retains the MCL standard for TCE, they may also require RMIES to clean up groundwater until all Site-related constituents meet MCLs. This might require additional activities to address nitrite and nitrate contamination and monitoring for lead and barium.

Radiological Parameters (RESRAD):

ODH has also indicated that it will accept calculations of site-specific exposure to radionuclides using the RESidual RADioactivity (RESRAD) computer code as developed by Argonne National Laboratory. RESRAD is a risk-based approach based on the following principles:

- that the annual radiation dose received by a member of the critical population group should be kept as low as reasonably achievable (ALARA); and
- that the annual radiation dose received by a member of the critical population group from the residual radioactive material encountered through nine potential pathways as predicted by a realistic but reasonably conservative analysis and calculated as a committed effective dose equivalents should be below target levels for expected future use scenarios.

ODH has indicated that it considers the appropriate dose standard to be 25 mRem/year for unrestricted future use under a “resident-farmer” scenario. ODH has not indicated any willingness to consider alternative scenarios even tied to significant future site use restrictions.

5.5 GEOLOGIC SETTING / IMPLICATIONS FOR CONSTITUENT TRANSPORT

As described above, SHARP developed a conceptual understanding for the Site lithologic setting that has ~3-5' of surficial, more-permeable soils underlain by oxidized till that has silt lenses. This is in-turn underlain by an unoxidized till that, in its undisturbed form, is essentially impermeable to groundwater (or constituent transport). Thus, in general, there is little transport from contaminant sources through the subsurface. The exceptions to the general lack of subsurface constituent transport are associated with the following:

- Surface water migration of sediment-associated or dissolved constituents, including those present in seep waters;
- Migration via vertical fractures, silt lenses, and other conduits in the FEP WMU; and
- Migration via utility lines or through other areas with disturbed soils;

Particulate-associated contaminants deposited on site surface soils:

Fine-particulate-associated contamination (U, Tc-99) is expected to migrate through more-permeable *surface* soils but is attenuated as soon as the constituents reach the less permeable tills; however, some localized migration may then occur in the disturbed soils or in the oxidized till through the more permeable silt seams.

Particulate-associated contaminants also will migrate as suspended solids via surface water pathways and (to a more limited extent) as airborne dusts. Thus, for Total U and Tc-99, SHARP expects that most of the site contamination above cleanup standards will be found in the uppermost soils and that groundwater wells that are NOT in communication with the surficial soils will likely not have Total U or Tc-99 in dissolved phase. Some Total U and Tc-99 may be found in the subsurface in the vicinity of utility drain lines – however, this is not expected to migrate far from these drain locations.

This Site Conceptual Model for migration and transport of the radiological parameters is confirmed by a review of recent soil boring data. SHARP collected all the data from 3 boring programs:

- The “L-series” borings installed in the FEP WMU;
- The SHARP boring program described in this report; and
- The “Baker” series borings installed across the site.

Approximately 220 borings were installed in these three programs with ~1287 soil samples collected and analyzed. SHARP graphed the Uranium concentrations of the “L-series” borings versus depth of sample (See Figure 5.1). This figure shows that of the 173 collected samples, 24 exceed the cleanup standard of 43 mg/kg. However, only 7 samples collected from a depth greater than 5’ exceed the cleanup standard; and each of these samples was collected from a more-permeable stratum (silt & clay, sand & clay, or gravel & clay).

The results of the other two boring programs are similar (see the following table):

Summary of Uranium Results from Boring Programs

Type of Boring	Results Range (mg/kg)	# of Samples	# Exceeding 43 mg/kg	% of Total	# Exceeding 43 mg/kg @>5'	% of Total	# Locations* >43 mg/kg & >5'
SHARP 2002	ND - 550	122	30	24.59%	1	0.82%	1
Baker Series Vertical	ND-501	578	51	8.82%	1	0.17%	1
Baker Series Slant	ND-3754	414	65	15.70%	9	2.17%	5
L-Series	ND-4980	173	24	13.87%	7	4.05%	4
All Boring Samples	ND-4980	1287	170	13.21%	18	1.32%	11

Only one SHARP boring sample collected from a depth greater than 5’ had a result that exceeded the cleanup standard. Only one *vertical* Baker boring sample collected from a depth greater than 5’ had a result greater than 43 mg/kg.

The *slant* Baker series borings are assumed to have been installed on a slant because of the proximity to either surface structures or buried utilities. Thus, these structures (and their

foundations) or the utilities may be acting as conduits for migration of particulates to depths greater than 5'. The 9 slant borings that exhibit uranium above its standard at a depth greater than 5' likely result from particulate-associated migration through disturbance of site soils, more-permeable zones in the vicinity of structures, or buried utilities.

A graph of the uranium results from all borings is presented as Figure 5.2. These results show that perhaps as much as 13% of the site surface soil may be uranium contaminated above 43 mg/kg and this contamination may have migrated to depths of up to 5' through relatively permeable surficial soils. In relatively few areas, more-permeable conduits may exist that allow migration to >5'. However, there is no need to postulate any groundwater migration pathway to explain any of the site uranium contamination (See additional discussion in next section).

Liquid and dissolved-phase contaminants (TCE):

TCE (as the free liquid or dissolved in water) will percolate through surface soils to the unoxidized till. It will follow groundwater migration pathways through silt lenses until the groundwater in these lenses reaches a surface water seep or until it reaches the unoxidized till contact. In the FEP WMU area, the site subsurface has been disturbed by:

- well completions that span permeable and non-permeable zones,
- prefabricated vertical drains;
- HRC injection points;
- utility line installation; and
- other historic site work.

At other Site locations there is little evidence of any constituent migration via traditional groundwater migration pathways. Although TCE is more mobile than the other site constituents due to its water solubility, it still does not transport significant distances in the subsurface at the Site in the absence of a conduit. Thus, most of the TCE has been found in the vicinity of its source(s).

This is evident in the FEP WMU area. This area has very high groundwater concentrations of TCE; however, wells located ~40' away have concentrations that are orders of magnitude lower. This concentration gradient would not persist in the absence of significant confining units. The TCE concentrations are typically found in more-permeable strata at the contact with an impermeable layer (See cross sections).

Similarly, dissolved constituents (like nitrates and nitrites) are also found in groundwater only at locations associated with the more permeable zones in the FEP WMU area.

Although the site conceptual model accounts for most of the found Site contamination, historic, undocumented (secondary) sources may be the cause of the anomalous detections. These secondary sources may be due to small historic spills or due to depositions with rainwater.

Utility Line as Conduit for Migration:

As a result of the lithologic setting, there is a potential for contaminant migration over long distances (from the source) only via conduits. One likely conduit is the outfall line located

between MH11 and MH1. However, this investigation has shown that the outfall line's ability to act as a conduit is limited because it is NOT filled with a more-permeable backfill that could also act as a conduit. Instead, the backfill is native material that may have originally contained silt lenses that were destroyed in the backfilling process. As a result, *the backfill is acting more as a plug* – causing any migration to occur at the interface between the backfill and the native materials. The backfill is NOT saturated. The plug may still allow the sewer line to act as a conduit, but *away from the site*. The line is not the likely cause of any found contamination at shallower depths at locations *on the site*.

5.6 IMPLICATIONS OF SITE CONTAMINANT TRANSPORT UNDERSTANDING

This conceptual Site understanding that shows only limited groundwater transport of constituents and much more significant surface-water and surface-water/sediment transport has several implications to the decontamination of the facility and its eventual release, as follows:

- Little additional characterization (if any) of *surface* soils is needed prior to remediation (by excavation) for *radiological* parameters as long as real-time or near-real-time methods can be used to screen site soils. Prior to excavation, the approximate areal extent of hotspots can be calculated to identify the maximum allowable concentration of uranium allowed at that location. After surgical excavation, the concentrations of residual uranium and Tc-99 should be documented and evaluated against cleanup standards. Excavation to 5 feet may be all that is needed in most areas of the site.
- When removing site utilities, structures, or other potential conduits, the presence of uranium or Tc-99 at depth should be monitored and removed if site cleanup levels are exceeded.
- Groundwater concentrations of uranium and Tc-99 are not expected to exceed standards as long as the sources are removed. Surface soil uranium has not migrated to a large extent into site wells (even those as shallow as 5 feet).
- If excavation of Site soils is part of the remedial approach to managing TCE, this excavation of TCE-contaminated soil (and more-permeable silt lenses) is likely to remediate the majority of the TCE in groundwater at the same time.

6.0 DISCUSSION OF RESULTS

6.1 GROUNDWATER FLOW / CONSTITUENT TRANSPORT

The Phase II work confirms the conceptual model of the site as one where groundwater flow is severely limited (0.01 – 0.07 ft/year in the till) by the low hydraulic conductivity of the subsurface strata. Groundwater flow is to the north / northwest but is not a significant mechanism of groundwater transport of constituents of concern.

Percolating rainwater may be allowing some constituent transport of suspended solids and dissolved phase constituents to the water table; but, outside the FEP WMU area, this transport effectively ends at the surface fill / till interface. Groundwater in the FEP WMU does transport through the relatively-more-permeable silt seams. Groundwater feeds seeps noted along the face of the escarpment. These seeps have the potential to allow constituents to migrate much more quickly as surface water. Site data shows TCE and Total U detected in the seeps sampled (November 2002).

Portions of the subsurface in the FEP WMU is a special case: portions of the groundwater in the FEP WMU may not exhibit the same characteristics of limited transport due to the presence of numerous potential conduits including the prefabricated vertical drains (installed to ~15'), borings used for injection of Hydrogen Release Compound (HRC), and wells installed (and/or screened/sandpacked) from the surface fill across multiple lithologic contacts.

Other potential conduits that may allow significant flow are:

- Silt lenses expressed at the surface that may allow rainwater (or surface water) percolation;
- Seep waters;
- Utility lines, including the 18-inch line that crosses the FEP WMU; and
- Several indications of seep flow were mapped; rates of seep flow were estimated. The end of the 18-inch outfall line has been plugged at MH-1.

6.2 GROUNDWATER RESULTS

Transects:

Eight groundwater samples were collected from temporary piezometers with the following results:

- TCE was found above the MCL at three locations,
 - Transect 1 [within the FEP WMU (Borehole 1B) at 3'-8'], 27.8 µg/L;
 - Transect 2 [within the FEP WMU (Borehole 2) at 4'-9'], 130 µg/L;
 - Transect 5 [near CEI Substation (Borehole 5D) at 5'-11' in a more-permeable zone], 12.8 µg/L.

The TCE source in the FEP WMU has been well documented. The TCE source near the Substation is unknown. This secondary source of TCE may be from percolation of TCE from atmospheric deposition of TCE with rainwater, or from TCE carried with roof drain

water to the subsurface, or from some other localized TCE source (historic spill?) in the vicinity of the substation, or from some complex migration from the FEP WMU via the drain.

- Total U was found above its MCL at four locations
 - Transect 2 [within the FEP WMU (Borehole 2B) at 4'-9', same location as TCE exceedance], 130 µg/L;
 - Transect 3 [not associated with any other groundwater contamination at 6'-11'], 105 µg/L;
 - Transect 5 [at same location as TCE exceedance in more-permeable stratum], 2490 µg/L;
 - Transect 8 [not associated with any other groundwater contamination at 4'-9', 103 µg/L.

The sources of these detections are not consistent with any other contaminant pattern. SHARP suspects that these uranium detections are associated with uranium contaminated soils that are present at depth due to historic rework of the site surface soils, perhaps including the excavations for installation of utilities. These detections may also be false positives due to uranium-contaminated sediments.

- Tc-99 was found above its MCL in one transect, Transect 2, associated with other groundwater contamination, 14,300 pCi/L.

Groundwater Monitoring Wells:

Sixteen (16) additional monitoring wells were installed to complete the delineation of contamination at the Site. The general conclusions are listed below.

- TCE plume is limited to the vicinity of the FEP WMU and predominantly in the till unit.
- Total U plume is limited to the FEP WMU and in the till unit
- Tc-99 plume is limited to the vicinity of the FEP WMU and in the till unit.
- MW-200, located within the FEP WMU and completed in the shale, is interpreted to be compromised based on the lack of water in the downgradient well MW-900 and the fact that the water level in the well more closely matches the till unit than other bedrock wells.

6.3 SOIL RESULTS

TCE:

One TCE sample (of 91 borehole soil samples analyzed for TCE) has concentrations that exceed the soil GCN (no groundwater) of 22.6 mg/kg [22,600 ug/kg]. That sample was collected from 14' in Borehole 1A (112,000 ug/kg).

Several other samples exceeded the most-conservative (leaching to groundwater) soil GCN of 20 ug/kg, but these results were limited to FEP WMU-area soils and soils around Transect 5 (near the substation). In combination with the groundwater results, these results support the conceptual model that shows little migration of constituents (away from site sources) via a traditional groundwater pathway.

Total U and Tc-99:

Thirty (of 122) uranium samples exceeded the soil standard of 43 mg/kg; however only 1 sample has Uranium present at >43 mg/kg at a depth greater than 5' – indicating that transport from the source via groundwater mechanisms is not significant (i.e., transport stopped at the surface fill/till interface for these samples). One Tc-99 sample slightly exceeds the soil standard of 65 pCi/g; however, this sample was collected from 3.2-feet. The groundwater sample results do NOT mirror the soil results. However, the soil results support the conceptual model that shows little migration of constituents via a traditional groundwater pathway.

6.4 CONSISTENCY WITH EARLIER RESULTS

Recent results are similar to historic data that support the conceptual model, as follows:

- *Wells* close to and downgradient from contaminated wells **are not as contaminated**; e.g., MW-501 had TCE at 173,000 µg/L in September 2002, but MW-502, a till well located less than 40 feet downgradient has a TCE concentration of 1190 µg/L;
- *Areas just downgradient of the FEP WMU are clean*, although portions of the FEP WMU area have been contaminated for over 17 years. An interface well screened only 16-feet deeper than MW-104 (MW-301) has TCE concentrations that are orders of magnitude less than those found in MW-104. This suggests that within the till unit, groundwater moves at a very slow rate.
- No TCE-contaminated wells are located outside the WMU areas. Transport via groundwater must therefore be slow since TCE was released to the Site in the early 1970s. Recent detections of TCE in the temporary piezometer (5B) at just above the MCL are not necessarily attributable to the FEP WMU source; other site spills or airborne deposition could account for it also.

Although the FEP WMU *soils* are significantly contaminated with TCE, Total U, and Tc-99, wells located downgradient, **within 200'** of the source are not contaminated. Wells located within 50' of

one another are contaminated at levels that vary over 3 orders of magnitude. This indicates that conduit flows are controlling.

- Although many Site soils have *surface* contamination of Total U and Tc-99 above cleanup standards, till wells completed within a few feet of the surface in those locations are not necessarily contaminated above cleanup standards, indicating that under current conditions, groundwater migration is very slow.
- A preliminary review of the Site setting and data against similar site and constituent conditions in Northeast Ohio shows other sites with similar contaminant migration behavior.

7.0 CONCLUSIONS AND RECOMMENDATIONS

The results of Phase II of the groundwater investigation at the RMI Site expand understanding of Site conditions and verify the conceptual groundwater model, which includes the following observations :

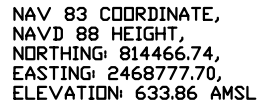
1. Groundwater transport (and associated contaminant transport) is very slow in the absence of conduits.
2. Site *groundwater* contamination is not laterally extensive – site contaminants remain close to source areas. Thus, contaminant sources do not have to be very extensive to account for all of the found groundwater contamination.
3. Other pathways (silt seams expressed at the surface, seeps / utility lines / other conduits) provide greater potential for contaminants to migrate.
4. Once source areas are cleaned up, residual groundwater contamination should not be extensive.
5. Major source areas are the FEP WMU and surface soils (for Total U and Tc-99)
6. A minor area of TCE contamination has been identified near the CEI substation. During its remediation, the source of this contamination may be elucidated.

The Phase II activities that are incomplete, are expected, when completed, to further confirm the site conceptual model and potentially identify and delineate additional minor source areas.

SHARP recommends that RMIES continue Phase II investigations until RMIES is confident that it can estimate the volumes of source areas contaminated above cleanup standards. That information will be needed to support remedial decision making.

8.0 REFERENCES

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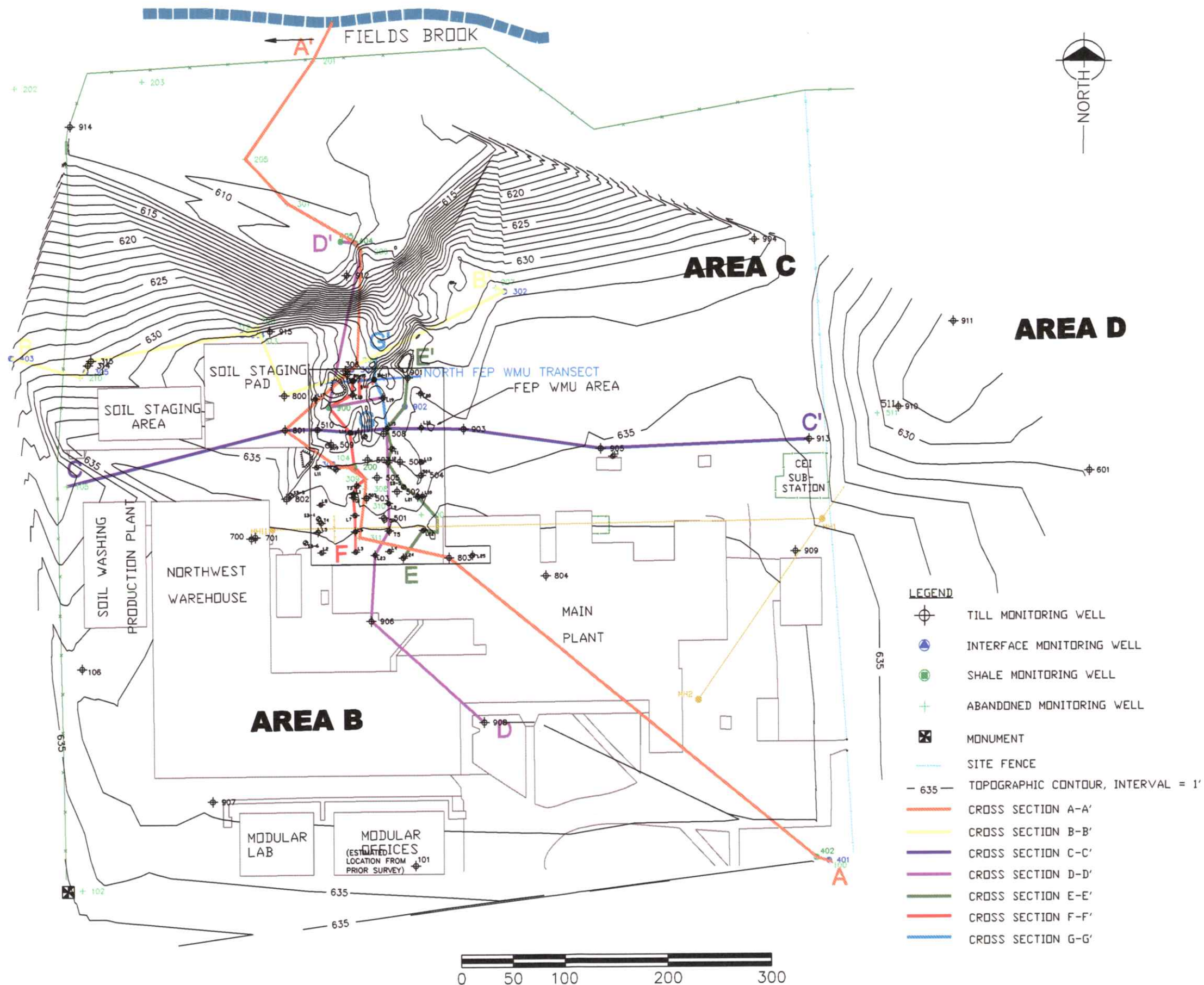
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AREA A

AREA B

AREA C

AREA D



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**BASE MAP SHOWING
LOCATIONS OF GEOLOGIC
CROSS SECTIONS**

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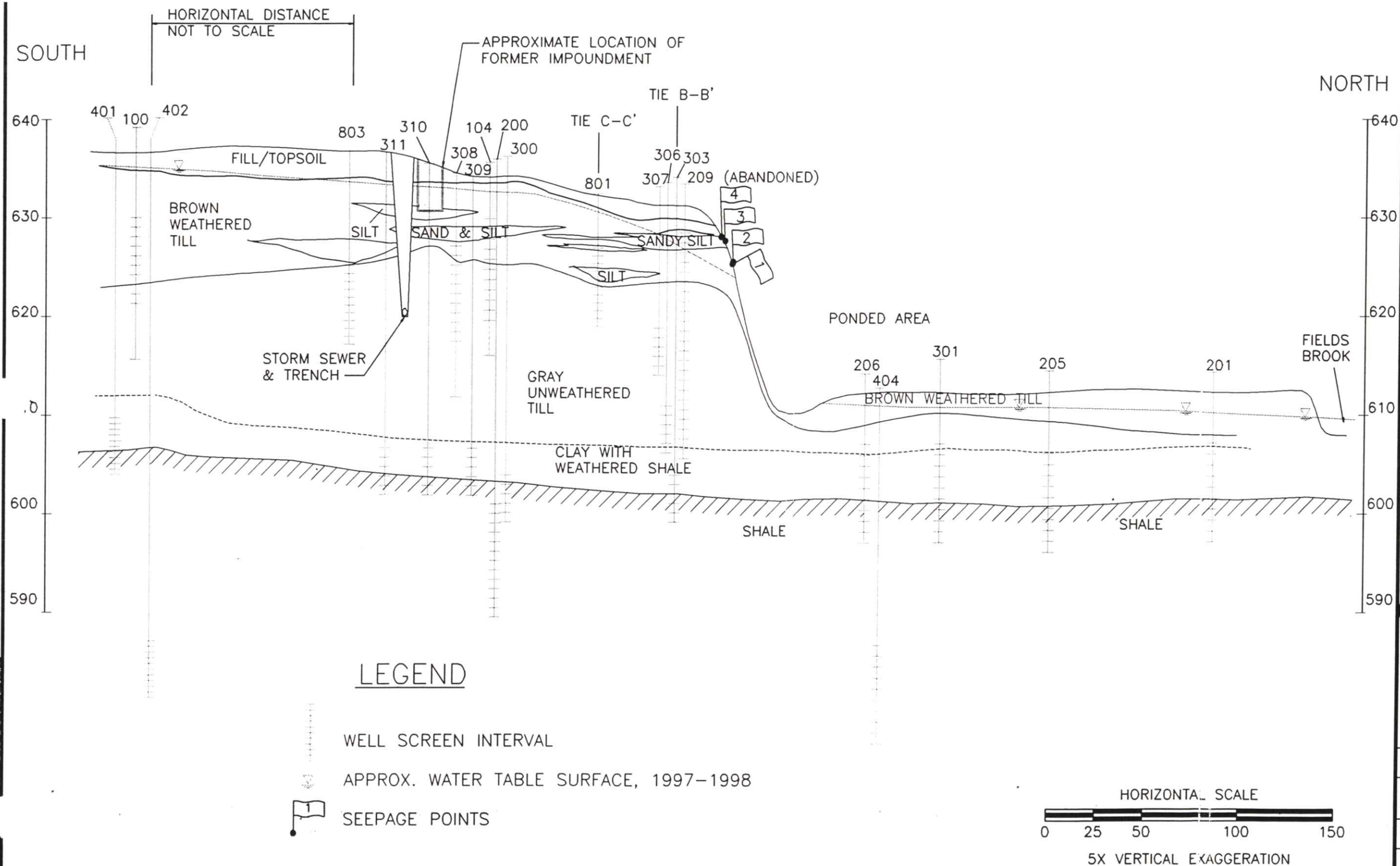
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GEOLOGIC CROSS-SECTION C-C

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The diagram is a geological cross-section of the FEP WMU AREA, oriented from D SOUTH (left) to D' NORTH (right). The vertical axis represents elevation in feet, ranging from 570 to 640. The horizontal axis represents distance, with a scale from 0 to 120 feet and an 8x vertical exaggeration.

Geological Layers (from top to bottom):

- TOPSOIL/FILL
- SILT
- CLAYEY SILT
- BROWN WEATHERED TILL \ FRACTURES
- GRAY UNWEATHERED TILL
- GRAY SHALE

Borings and Well Screen Intervals:

- 908:** Well screen interval from approximately 615 to 625 feet.
- 906:** Well screen interval from approximately 615 to 625 feet.
- L-23, T5, L-9, L-12, L-15, L-19:** Borings without well completions, indicated by vertical lines.
- 900:** Boring without well completion.
- 206/404/405:** Well screen interval from approximately 575 to 610 feet.
- 206:** Well screen interval from approximately 605 to 610 feet.
- 404/405:** Well screen interval from approximately 575 to 610 feet.

Projected Seepage Points:

- Points 1, 2, 3, and 4 are marked on the right side of the cross-section, near the surface.

Legend:

- WELL SCREEN INTERVAL (represented by a vertical line with horizontal tick marks)
- PROJECTED SEEPAGE POINTS (represented by a flag with a number)

Horizontal Scale: 0 to 120 feet. 8x VERTICAL EXAGGERATION.

TIE C-C': A line indicating the cross-section line across the top of the diagram.

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GEOLOGIC CROSS-SECTION D-D'

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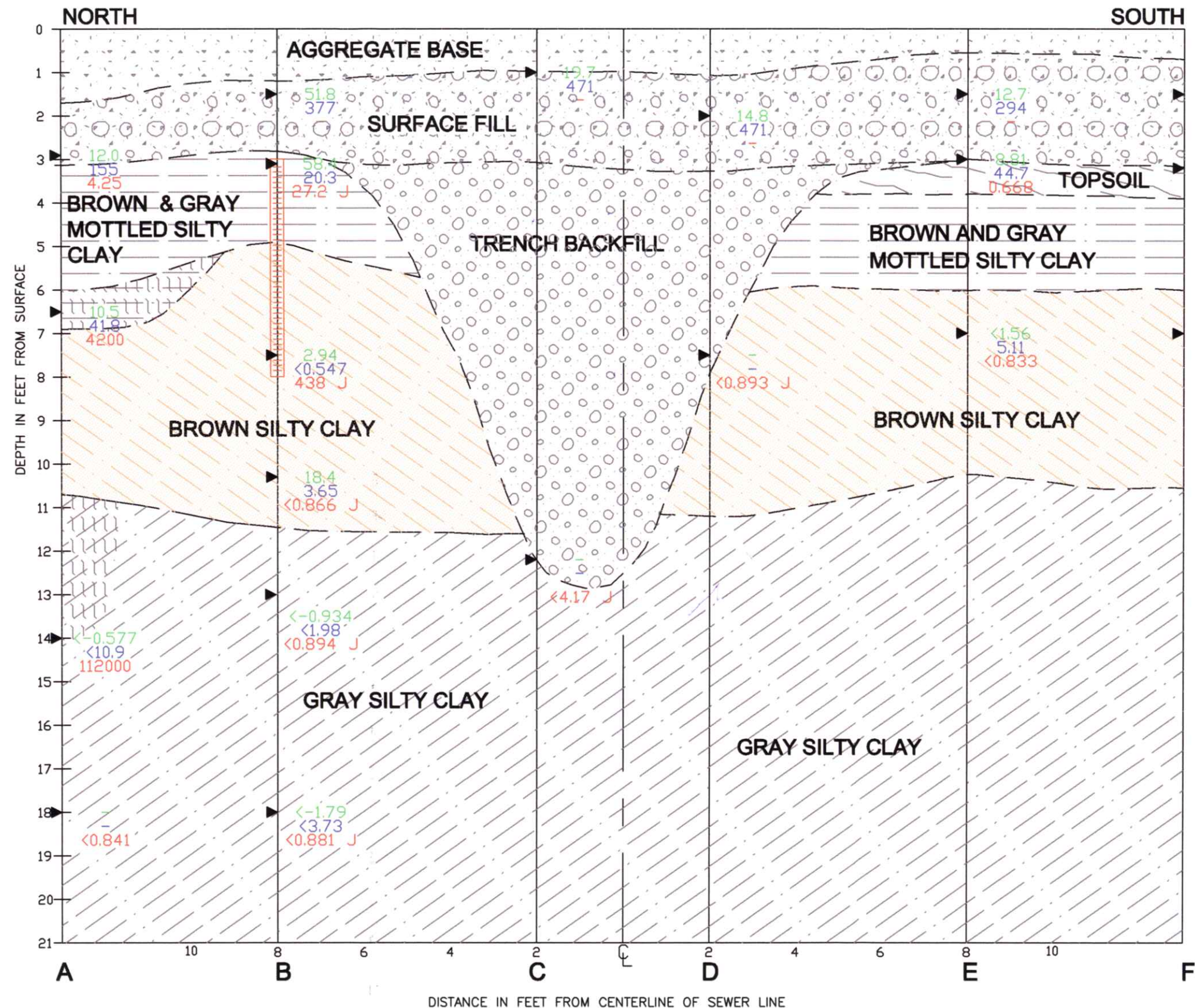
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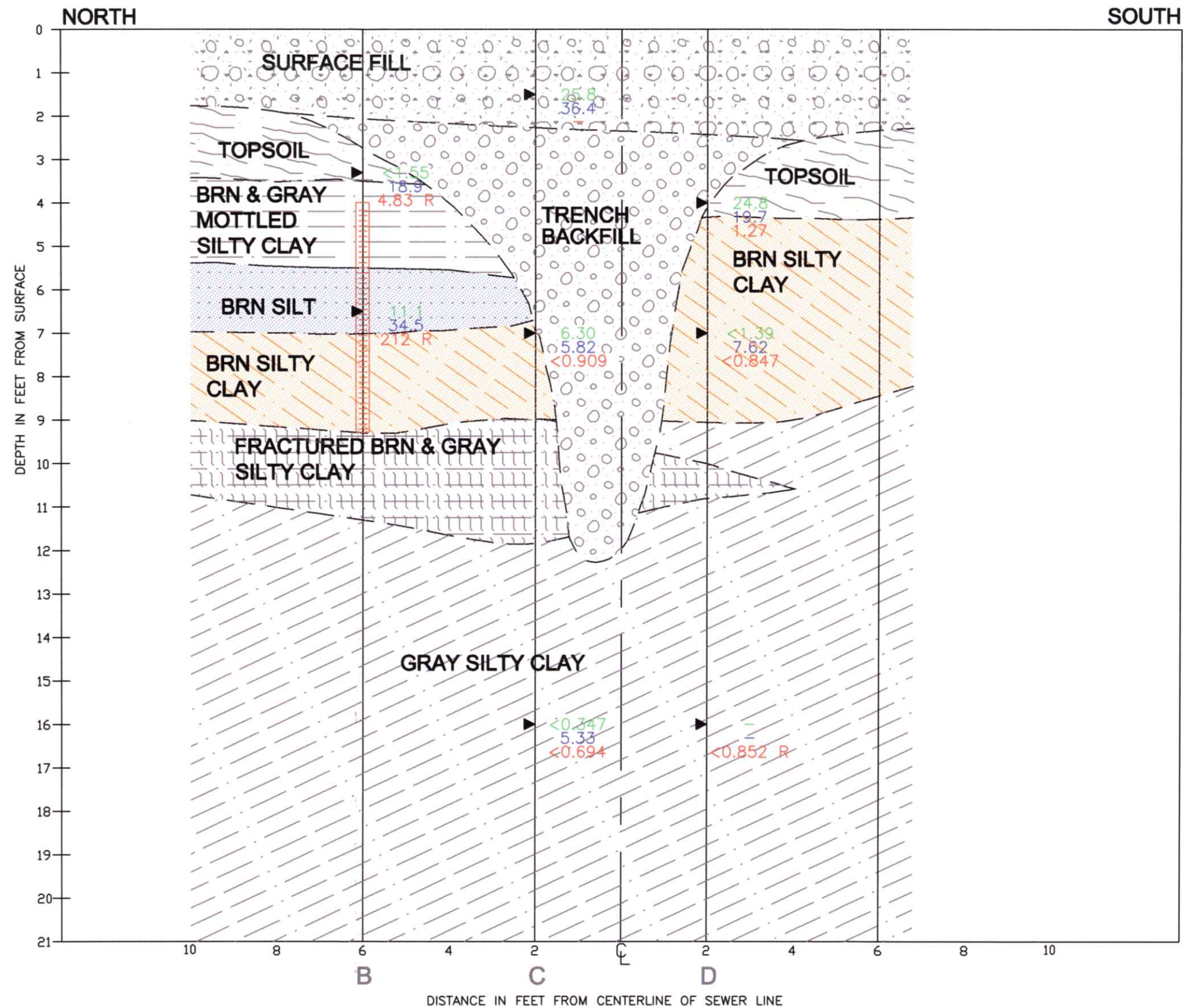
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- XXX = TOTAL U IN SOILS, ug/g
- XXX = TCE IN SOILS, ug/kg
- ▶ = AVERAGE SAMPLE DEPTH
- AGGREGATE BASE
- SURFACE FILL MATERIALS
- TRENCH FILL MATERIALS
- BROWN AND GRAY MOTTLED SILTY CLAY
- GRAY SILTY CLAY
- BROWN SILTY CLAY
- SAND
- SILT
- TOPSOIL-(SILTY CLAY)
- CLAYEY SILT
- CLAY
- GRAY SILTY CLAY WITH IRON
- FRACTURES

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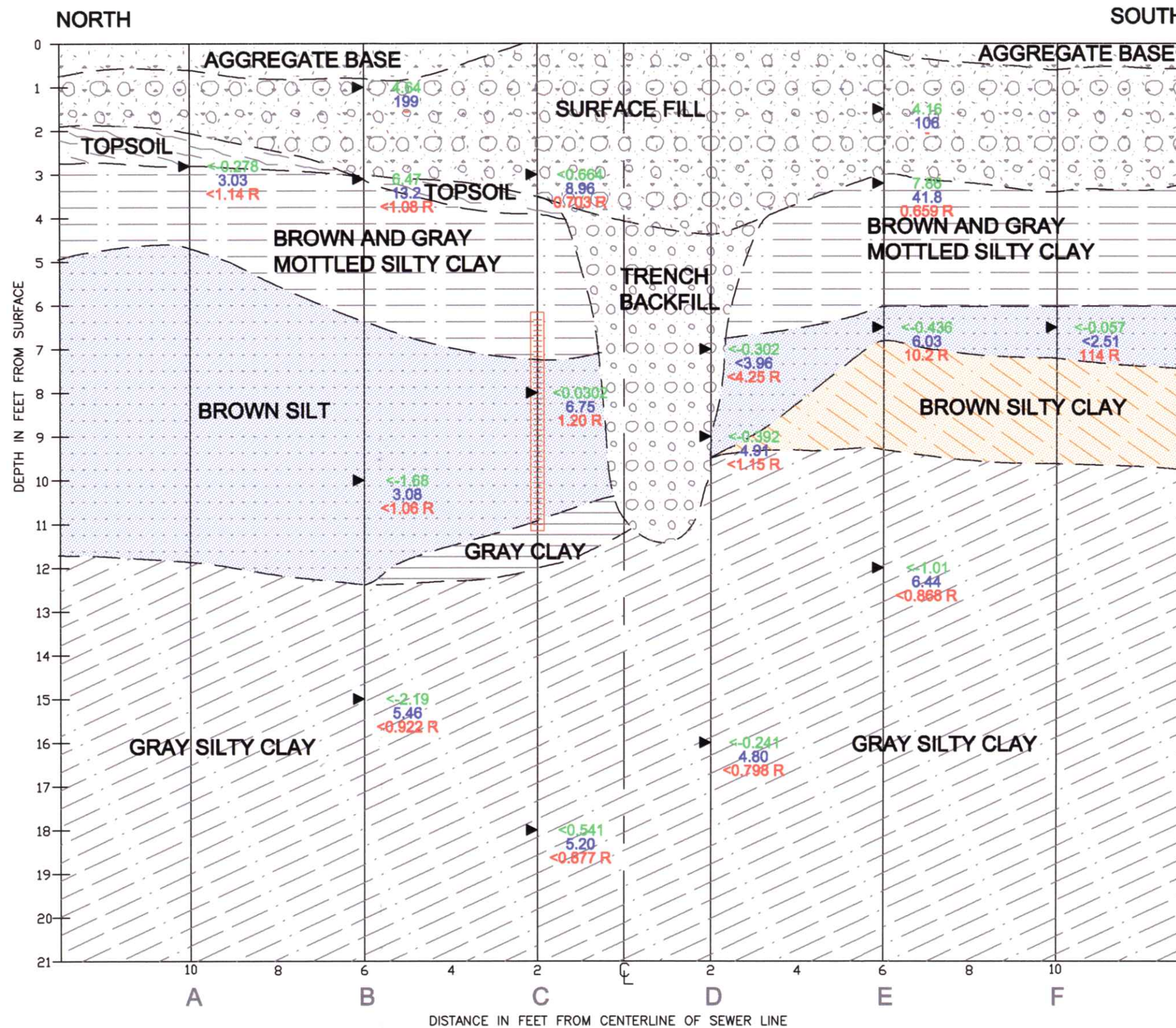
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AGGREGATE BASE	
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XXX = TCE IN SOILS, ug/kg
▶ = AVERAGE SAMPLE DEPTH

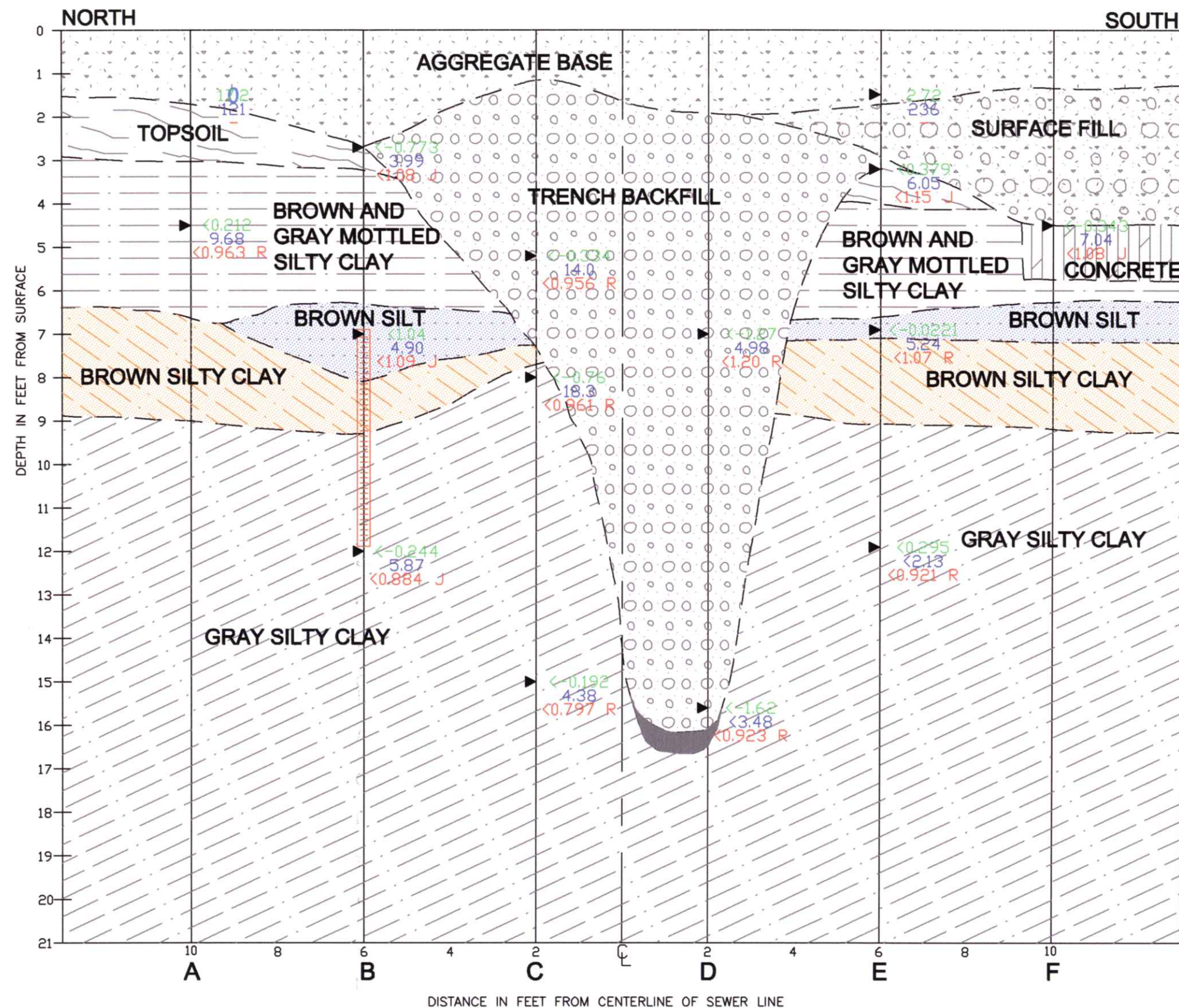
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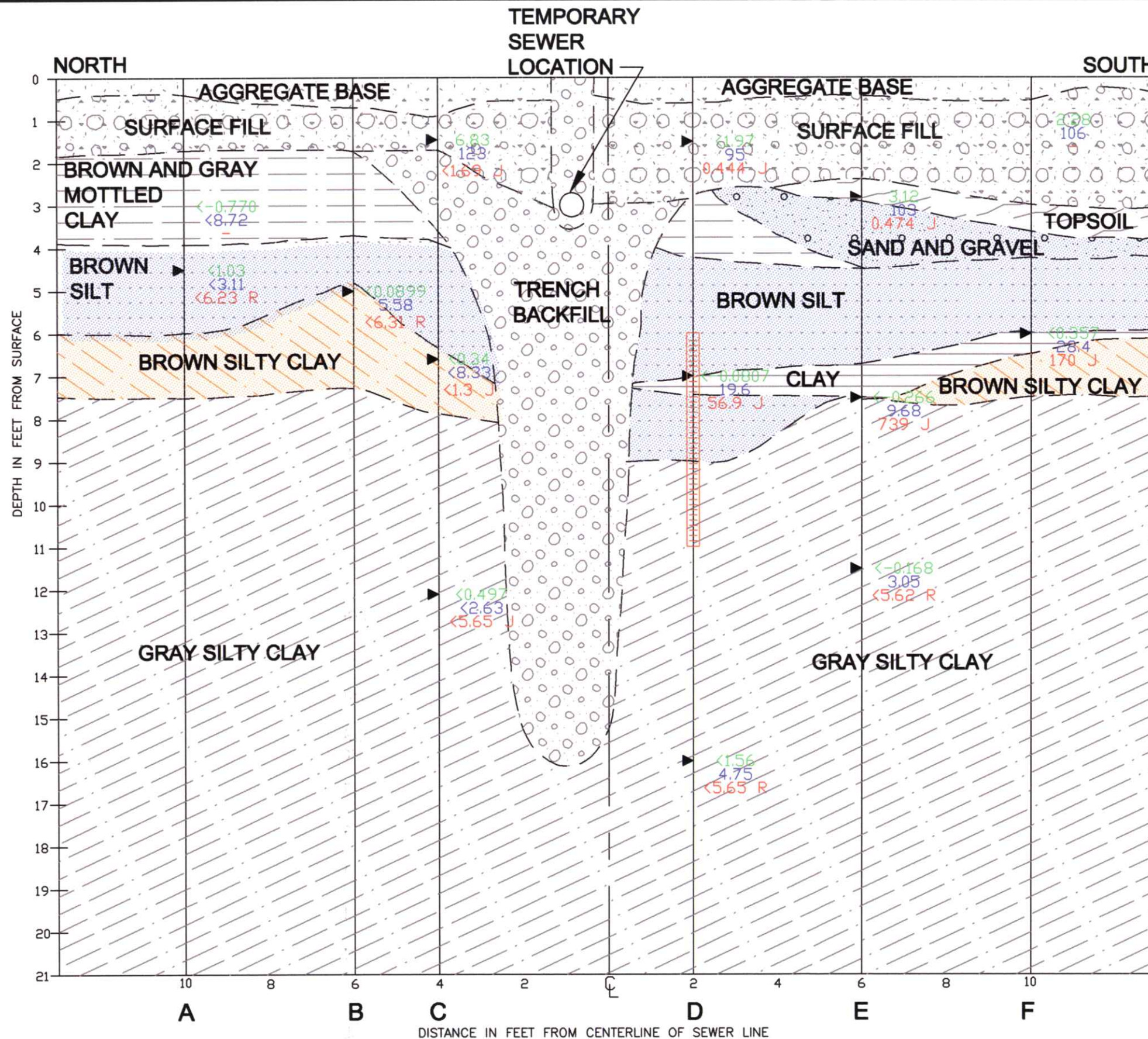
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 - SURFACE FILL MATERIALS
 - TRENCH FILL MATERIALS
 - BROWN AND GRAY MOTTLED SILTY CLAY
 - GRAY SILTY CLAY
 - BROWN SILTY CLAY
 - SAND
 - SILT
 - TOPSOIL-(SILT CLAY)
 - CLAYEY SILT
 - CLAY
 - SAND AND GRAVEL

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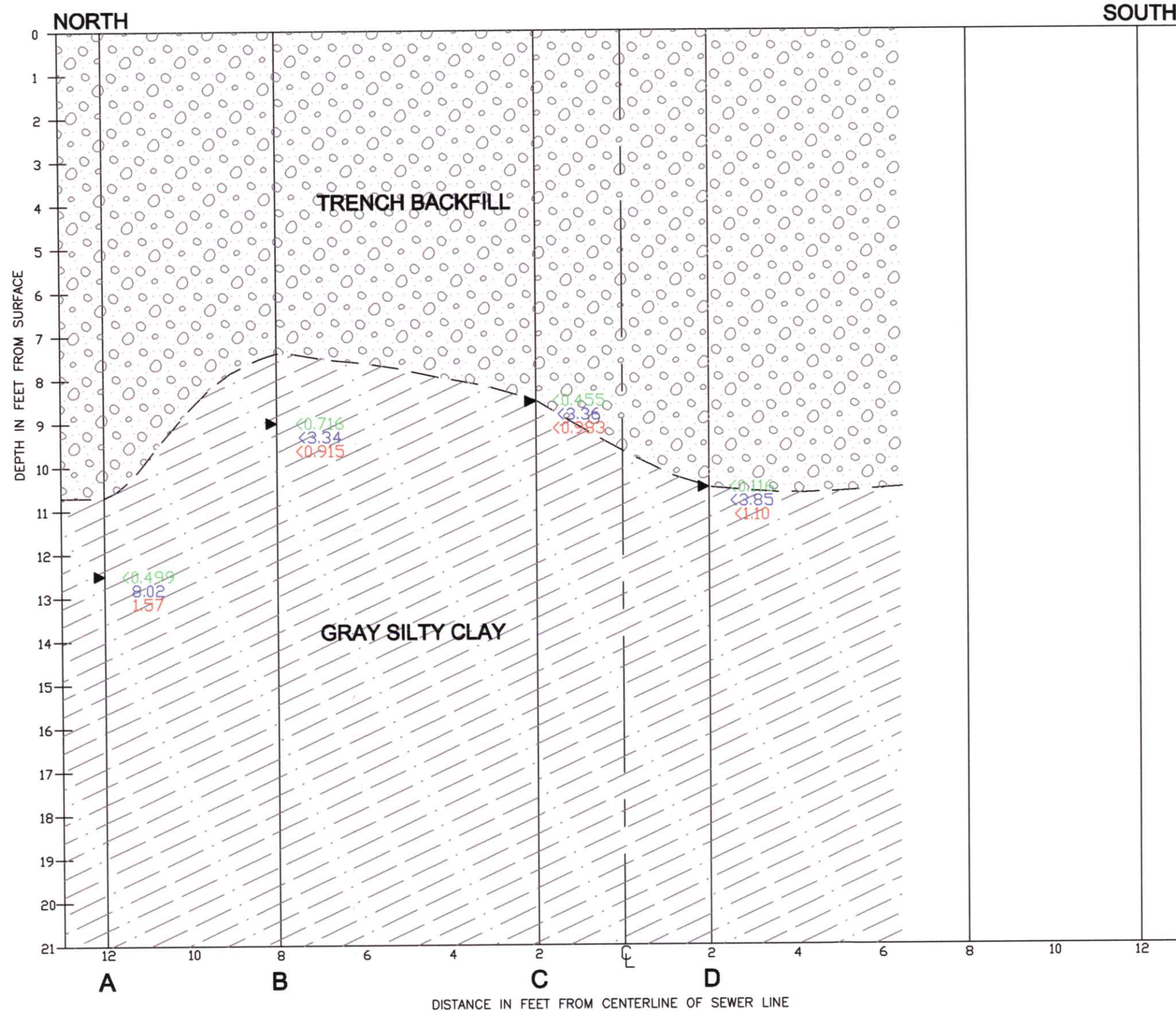
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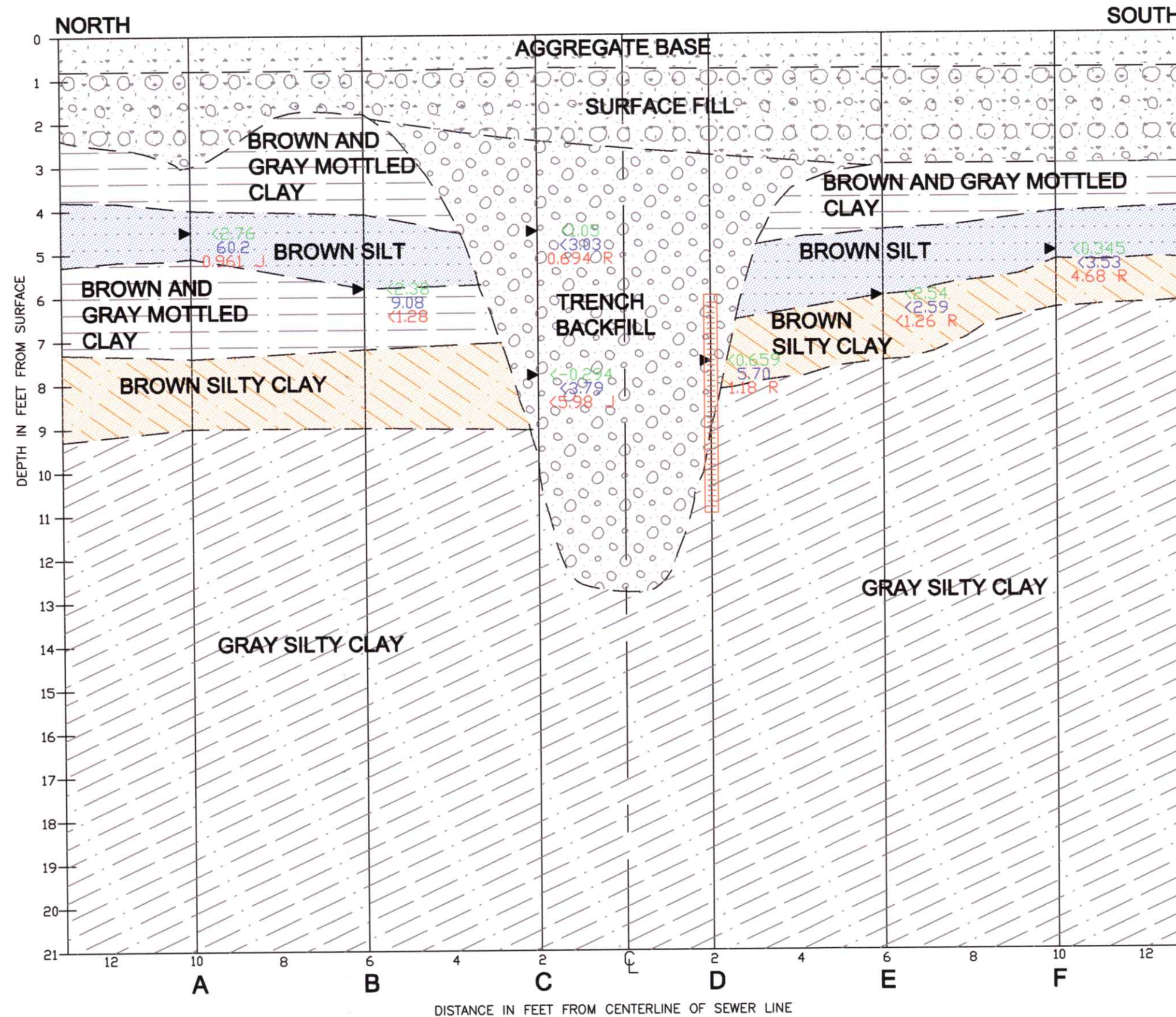
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- ▶ = AVERAGE SAMPLE DEPTH
- AGGREGATE BASE
 - SURFACE FILL MATERIALS
 - TRENCH FILL MATERIALS
 - BROWN AND GRAY MOTTLED SILTY CLAY
 - GRAY SILTY CLAY
 - BROWN SILTY CLAY
 - SAND
 - SILT
 - TOPSOIL-(SILTY CLAY)
 - CLAYEY SILT
 - CLAY
 - GRAY SILTY CLAY WITH IRON

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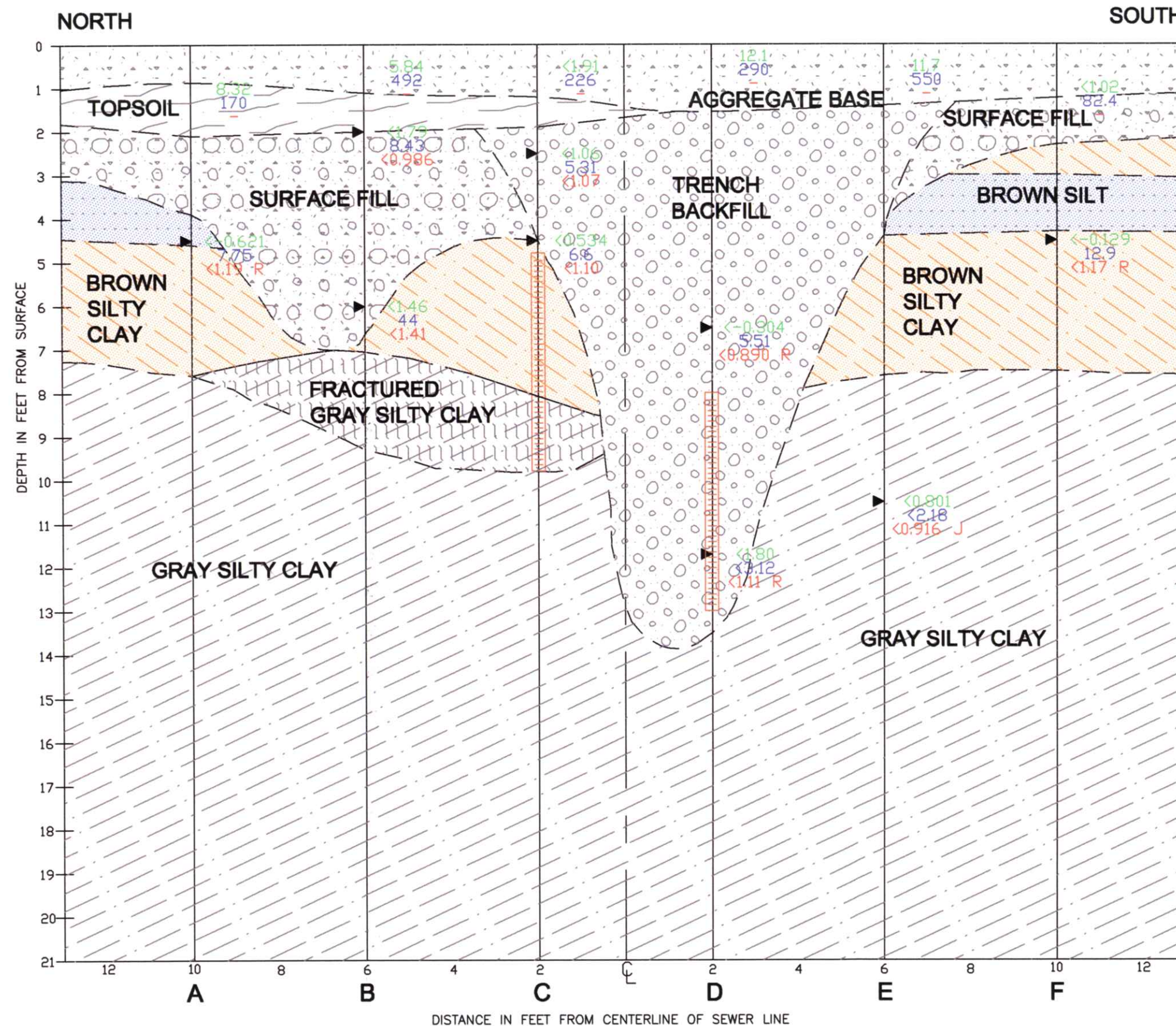
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Figure No.

Revision

3.7

2



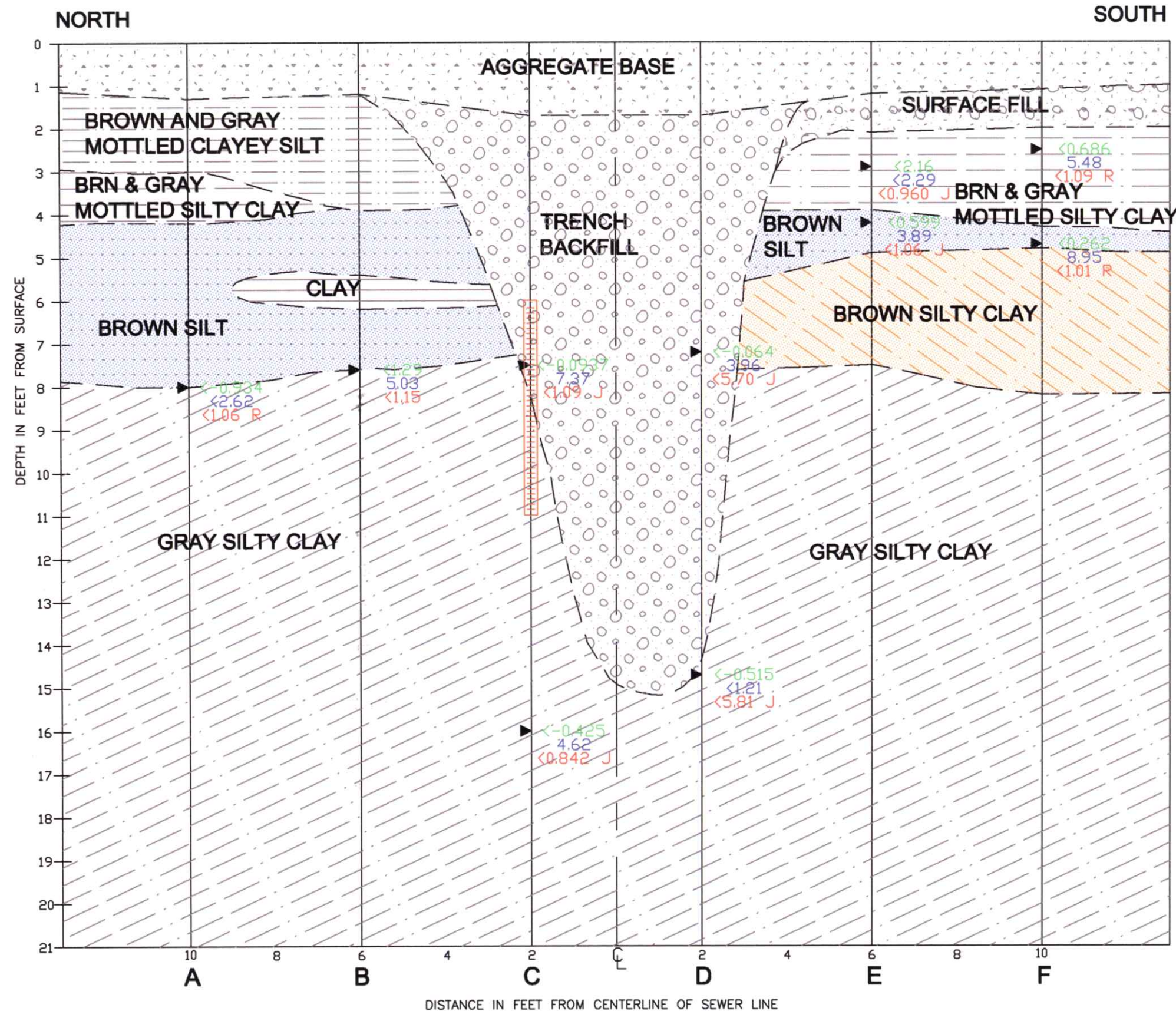
Rev.		Date	Description	Design Drawn Check

RMI ENVIRONMENTAL SERVICES
EXTRUSION PLANT SITE
ASHTABULA, OH

**GEOLOGIC CROSS SECTION OF
TRANSECT #8**

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AND ASSOCIATES, INC.
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Fax (614) 841-4660
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3.8.dwg
Project No.
2116
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Figure No. **3.8** Revision **2**



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ASHTABULA, OH

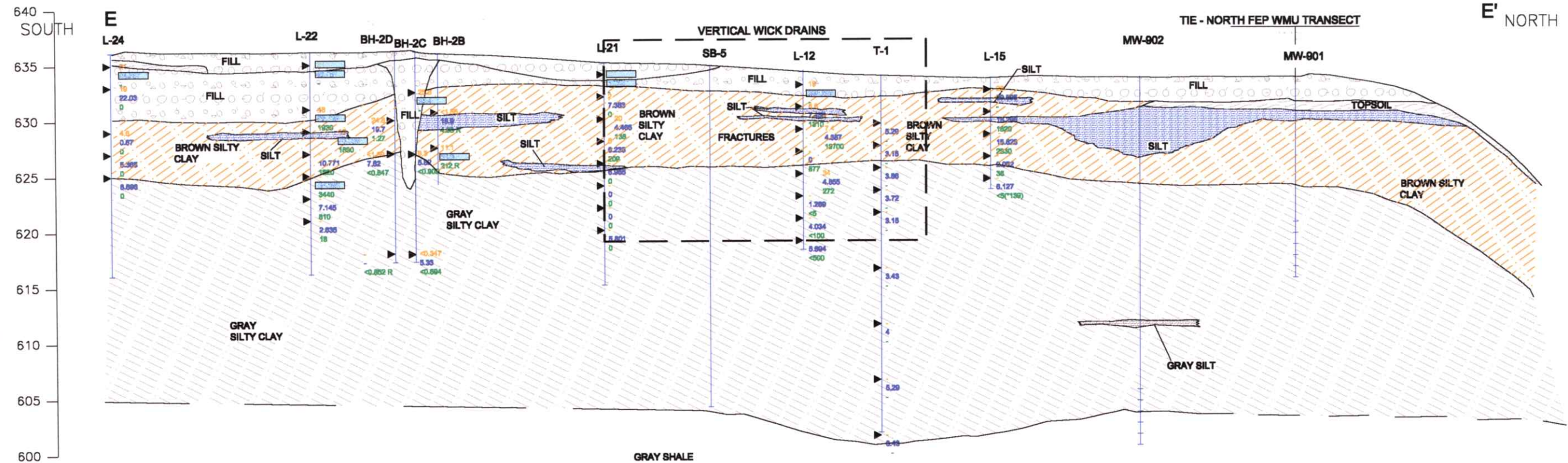
GEOLOGIC CROSS SECTION OF TRANSECT #9

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3.9.dwg
Project No.
2116




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Figure No. 3.9
Revision 2

Rev. Date Description Design Drawn Check



LEGEND


XXX = TC-99 IN SOILS, pci/g
 XXX = TOTAL U IN SOILS, ug/g
 XXX = TCE IN SOILS, ug/kg
 ► = AVERAGE SAMPLE DEPTH


	TRENCH FILL MATERIALS
	SURFACE FILL MATERIALS
	BROWN AND GRAY MOTTLED SILTY CLAY


 GRAY SILTY CLAY

 BROWN SILTY CLAY

 SAND

-  SILT
-  TOPSOIL—(SILTY CLAY)
-  CLAYEY SILT

 CLAY

 GRAY SILTY CLAY
WITH IRON

(*) Duplicate result; unable to verify concentration.

RMI ENVIRONMENTAL SERVICES
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GEOLOGIC CROSS-SECTION E-E'

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File Name
3.12rev2.dwg
Project No.

2116

Sheet of

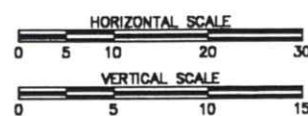
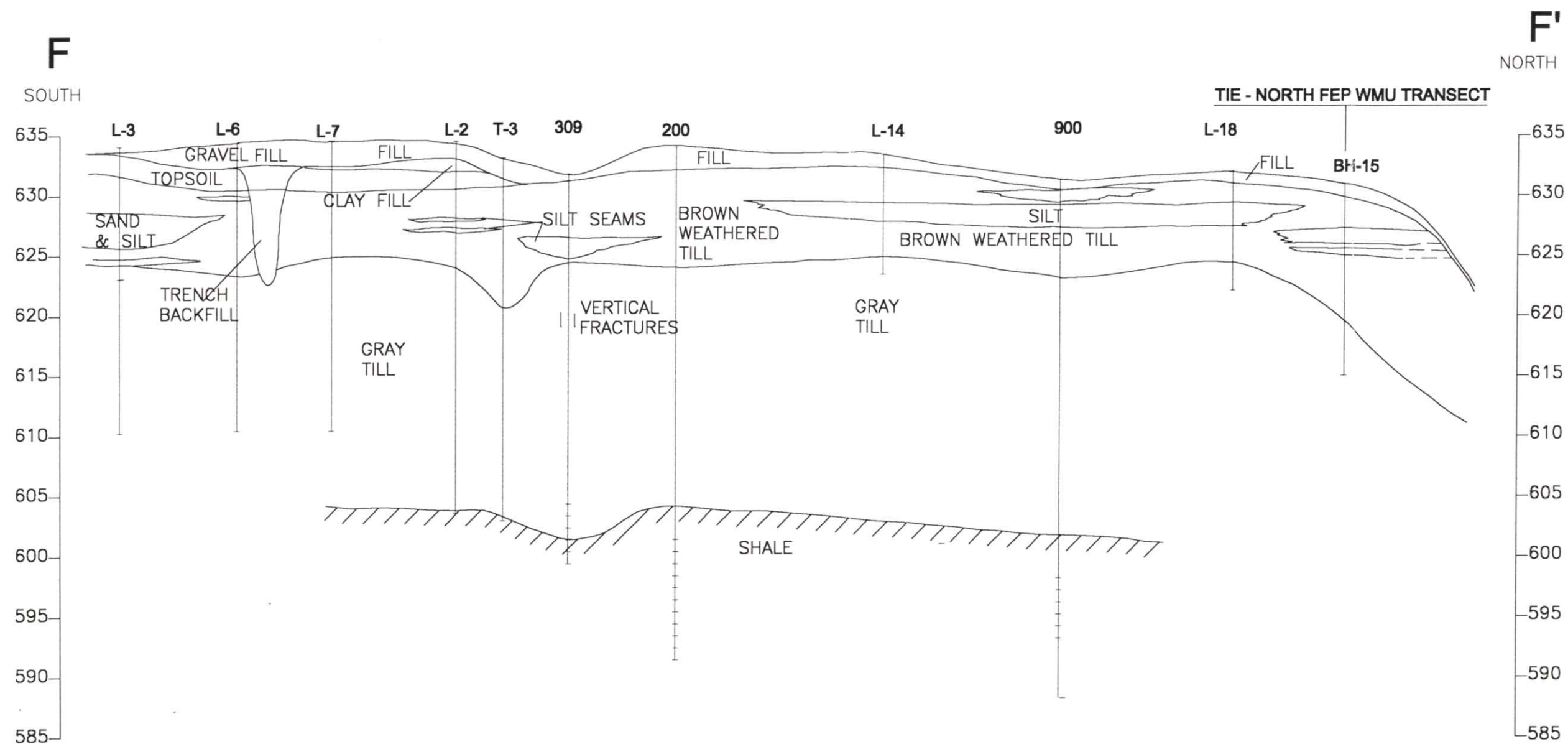
Revision

3.12

2 |

[illegible]

FEP - WMU DETAIL CROSS SECTION F-F'



LEGEND

WELL SCREEN INTERVAL

RMI ENVIRONMENTAL SERVICES
EXTRUSION PLANT SITE
ASHTABULA, OH

GEOLOGIC CROSS-SECTION F-F'

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Project No.	

2116

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Figure No.	Revision
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3.13

—

NOTE: SHEET REDUCED BY HALF FOR PRINTING

G

635
630
625
620
615
610
605

G'

A vertical axis with tick marks at 605, 610, 615, 620, 625, 630, and 635.

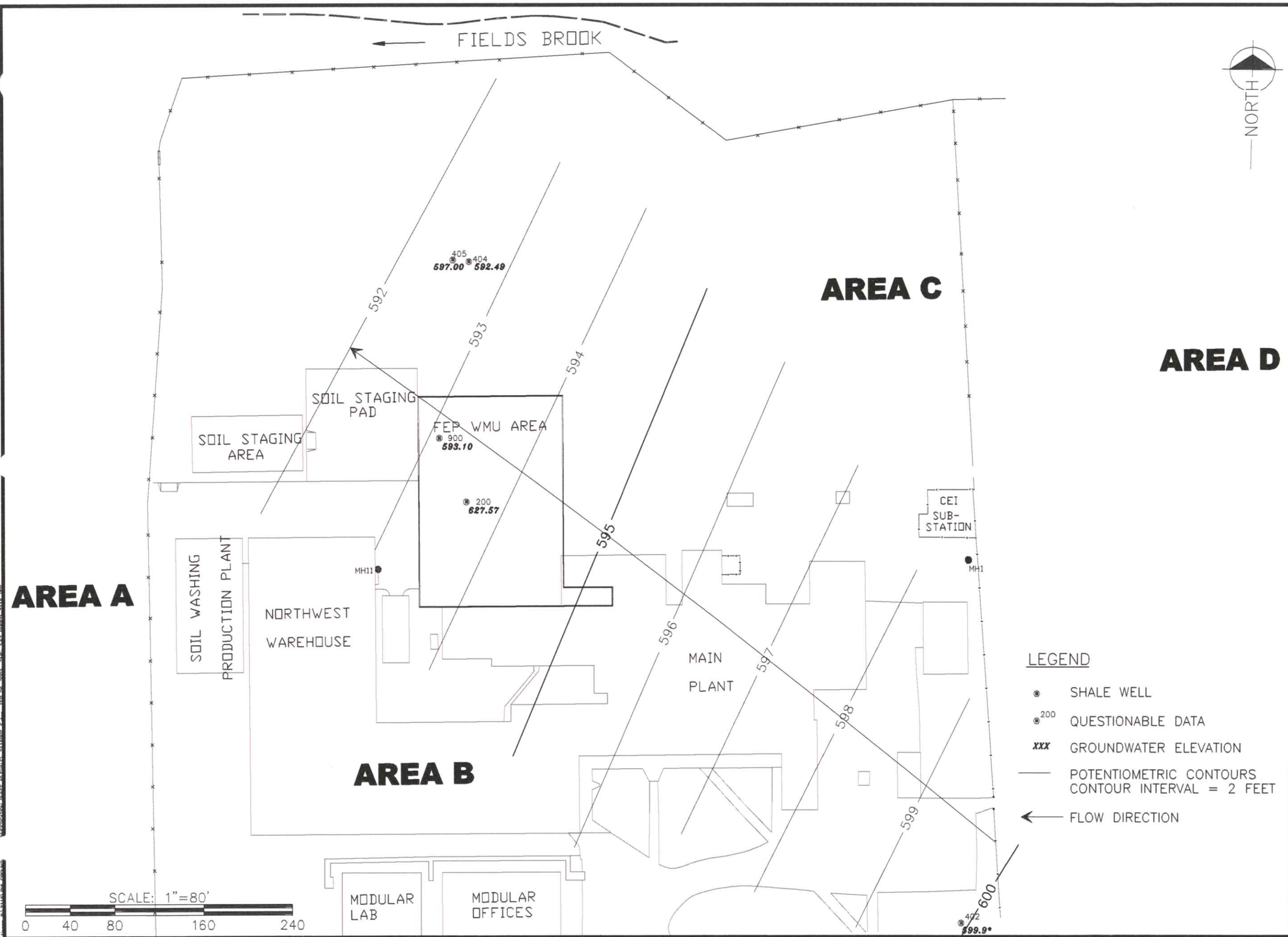


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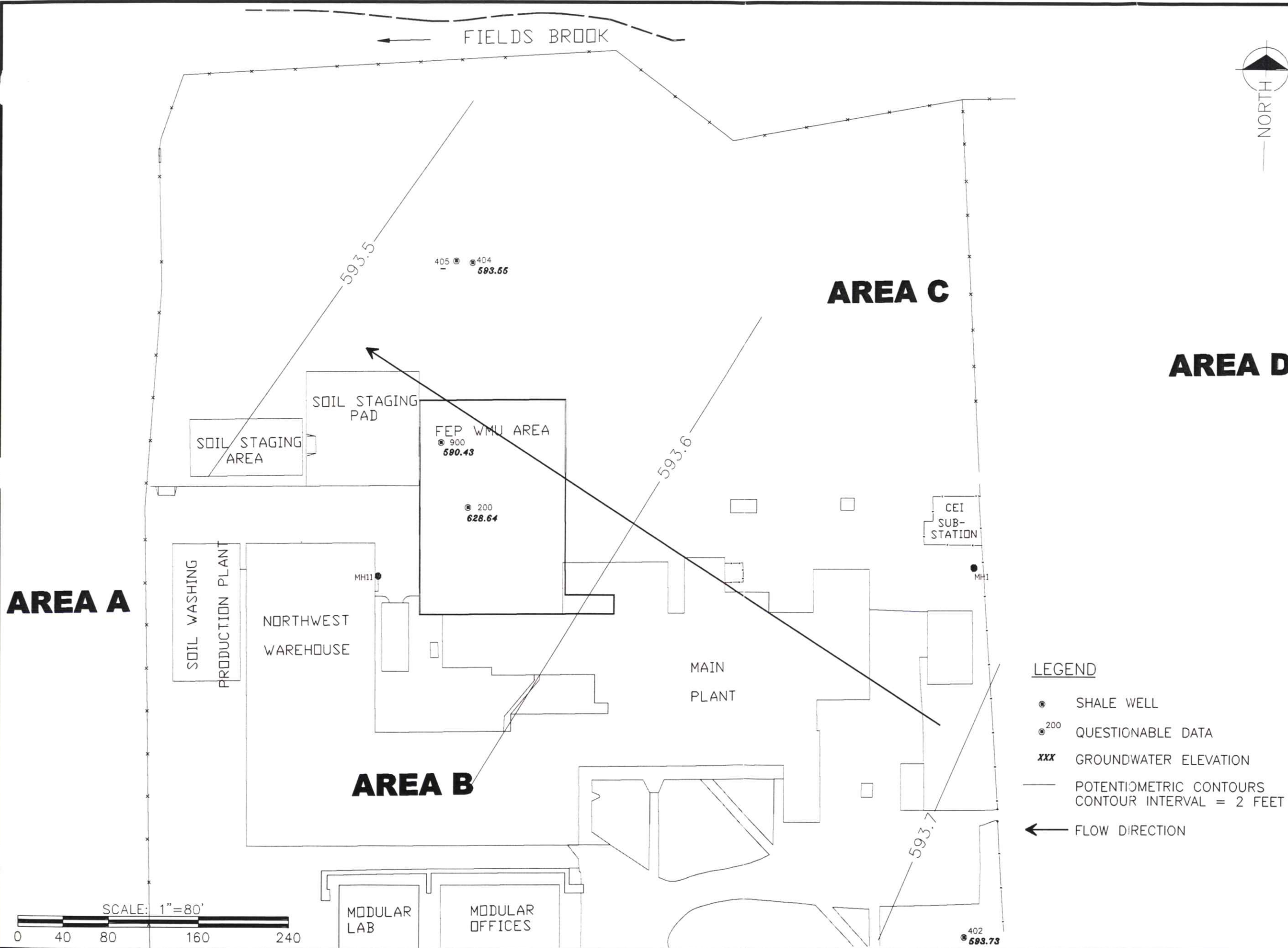
GEOLOGIC CROSS-SECTION G-G'

1




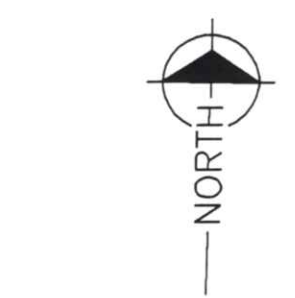
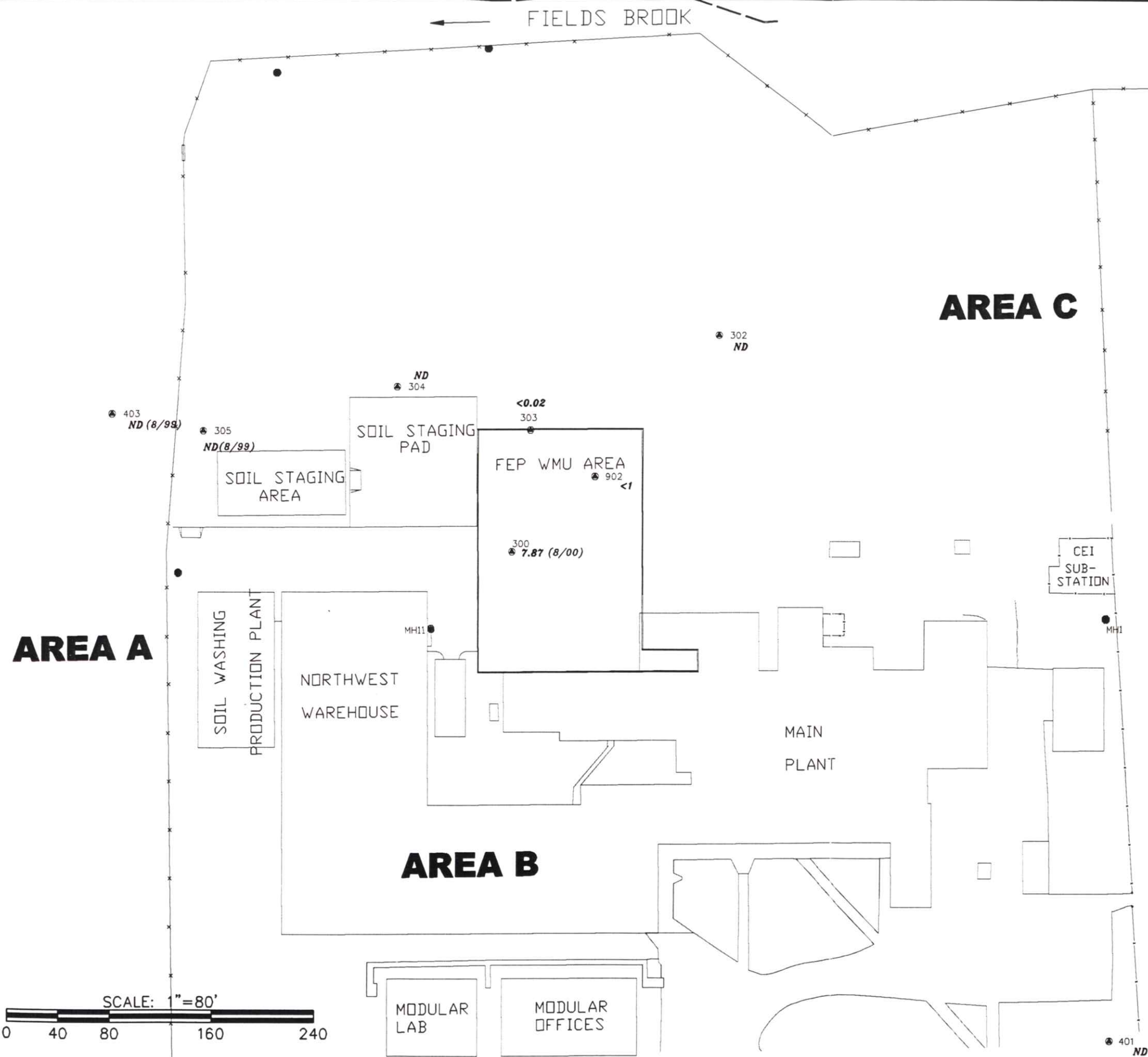
- LEGEND**
- SHALE WELL
 - ⊙²⁰⁰ QUESTIONABLE DATA
 - XXX GROUNDWATER ELEVATION
 - POTENTIOMETRIC CONTOURS
CONTOUR INTERVAL = 2 FEET
 - ← FLOW DIRECTION

POTENTIOMETRIC MAP SHALE WELLS JAN. 3, 2003 WATER LEVEL MEASUREMENTS		RMi ENVIRONMENTAL SERVICES PLANT EXTRUSION SITE ASHTABULA, OHIO
 <small>982 Crupper Avenue Columbus, Ohio 43229 (614) 841-4650 Fax (614) 841-4660 www.sharpenv.com</small>		File Name 4.3.dwg
Project No. 2116		Sheet of 4.3 2
Figure No. Revision 4.3 2		Rev. Date Description Design Drawl Check



- LEGEND**
- SHALE WELL
 - ²⁰⁰ QUESTIONABLE DATA
 - XXX GROUNDWATER ELEVATION
 - POTENTIOMETRIC CONTOURS
CONTOUR INTERVAL = 2 FEET
 - ← FLOW DIRECTION

RMI ENVIRONMENTAL SERVICES PLANT EXTRUSION SITE ASHTABULA, OHIO		POTENTIOMETRIC MAP SHALE WELLS MAY, 2003 WATER LEVEL MEASUREMENTS	
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Project No.		2116	
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Figure No.	Revision		
4.3A	0		



LEGEND

- INTERFACE MONITORING WELL
- SITE FENCE
- XXX** TCE CONCENTRATION IN µg/L
- DATA NOT AVAILABLE
- J** ESTIMATED VALUE
- ND** NOT DETECTED

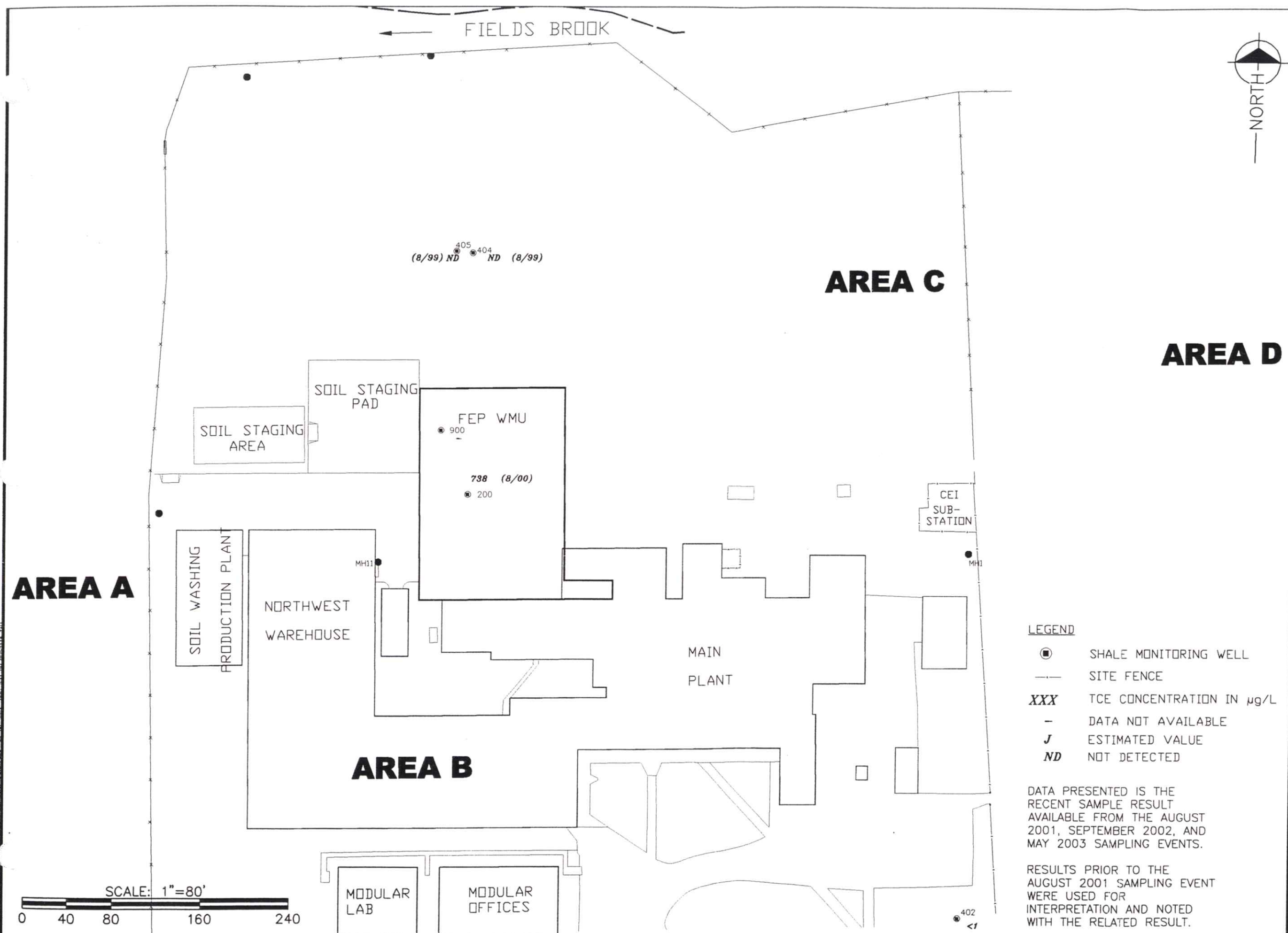
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RESULTS PRIOR TO THE AUGUST 2001 SAMPLING EVENT WERE USED FOR INTERPRETATION AND NOTED WITH THE RELATED RESULT.

RMI ENVIRONMENTAL SERVICES EXTRUSION PLANT SITE ASHTABULA, OHIO		TCE CONCENTRATIONS IN INTERFACE WELLS		Rev.	Date	Description	Design	Drawn	Check

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Project No. 2116	
Sheet 4.5	of 3
Figure No.	Revision

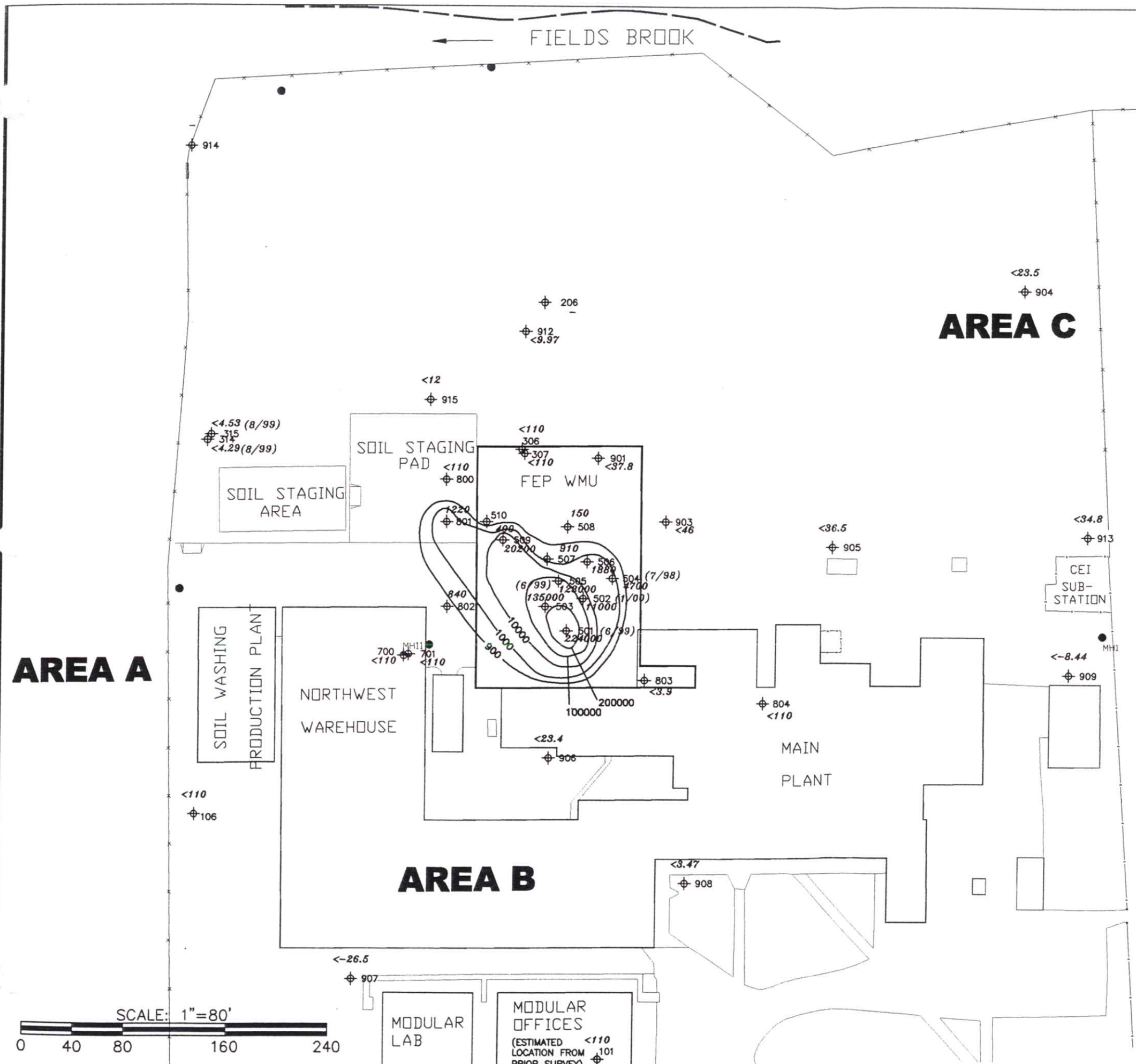


- LEGEND**
- SHALE MONITORING WELL
 - SITE FENCE
 - XXX TCE CONCENTRATION IN $\mu\text{g/L}$
 - DATA NOT AVAILABLE
 - J ESTIMATED VALUE
 - ND NOT DETECTED

DATA PRESENTED IS THE RECENT SAMPLE RESULT AVAILABLE FROM THE AUGUST 2001, SEPTEMBER 2002, AND MAY 2003 SAMPLING EVENTS.

RESULTS PRIOR TO THE AUGUST 2001 SAMPLING EVENT WERE USED FOR INTERPRETATION AND NOTED WITH THE RELATED RESULT.

TCE CONCENTRATIONS IN SHALE WELLS		Rev.	Date	Description	Design/Drawn/Check
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Project No. 2116					
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Figure No. 4.6		Revision 3			



FIELDS BROOK



AREA C

AREA D

AREA A

AREA B

MAIN
PLANT

NORTHWEST
WAREHOUSE

MODULAR
OFFICES
(ESTIMATED LOCATION FROM
PRIOR SURVEY) $\angle 110$
101

MODULAR
LAB


SOIL STAGING
AREA

SOIL STAGING
PAD <110

FEP WMU

SOIL WASHING
PRODUCTION PLAN

LEGEND

- | | |
|---|--------------------------------|
|  | TILL MONITORING WELL |
| — | SITE FENCE |
| XXX | TC99 CONCENTRATION
IN pCi/L |
| - | DATA NOT AVAILABLE |
| J | ESTIMATED VALUE |
| ND | NOT DETECTED |

DATA PRESENTED IS THE RECENT
SAMPLE RESULT AVAILABLE FROM
THE AUGUST 2001, SEPTEMBER
2002, AND MAY 2003 SAMPLING
EVENTS.

RESULTS PRIOR TO THE AUGUST 2001 SAMPLING EVENT WERE USED FOR INTERPRETATION AND NOTED WITH THE RELATED RESULT.

RMI ENVIRONMENTAL SERVICES
 EXTRUSION PLANT SITE
 ASHTABULA, OHIO

TC99
ISOCONCENTRATION
IN TILL WELLS

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Project No.

2116

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Figure No.	Revision
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4.10

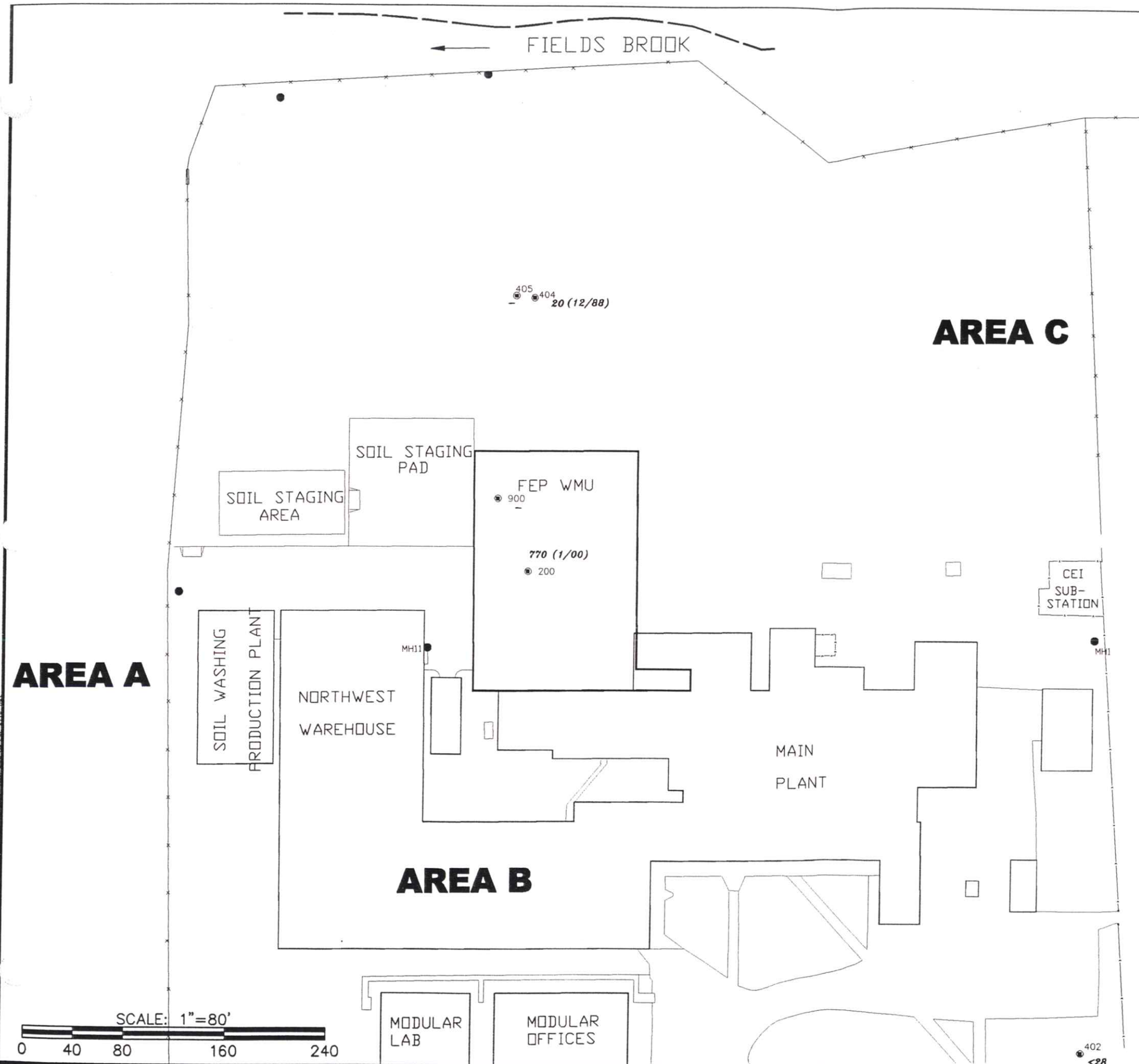
3

[illegible]

TC99

ISOCONCENTRATION
IN TILL WELLS

The logo for Sharp and Associates, Inc. features the word "SHARP" in a large, bold, serif font. Below it, "AND ASSOCIATES, INC." is written in a smaller, bold, sans-serif font. The contact information includes the address "982 Crupper Avenue, Columbus, Ohio 43229", the phone number "(614) 841-4650", the fax number "Fax (614) 841-4660", and the website "www.sharpenv.com".



FIELDS BROOK

AREA C

AREA A

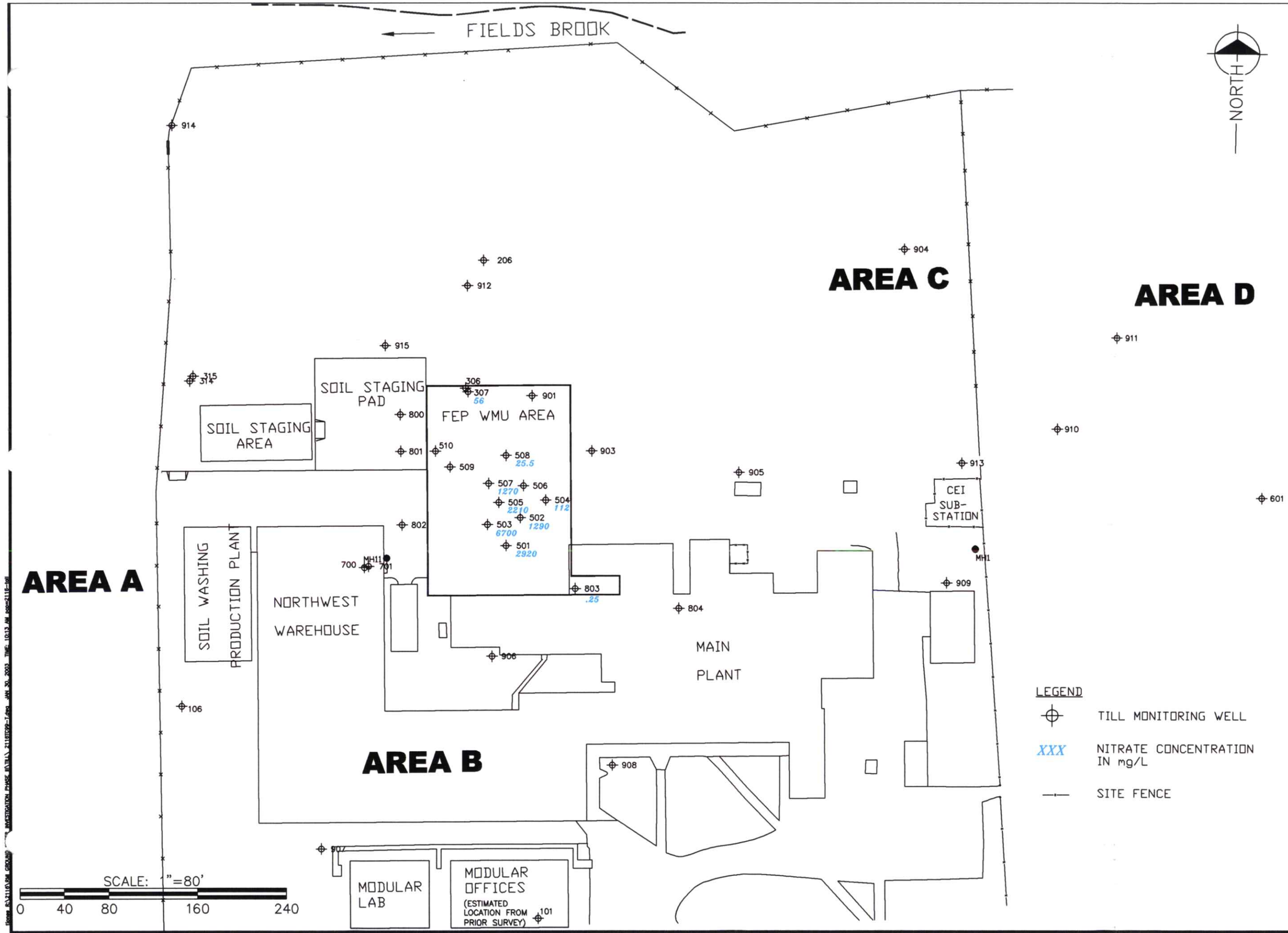
SOIL STAGING
AREA

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Description

Date _____

Rev.



Rev.	Date	Description	Design	Drawn	Check

RMI ENVIRONMENTAL SERVICES
EXTRUSION PLANT SITE
ASHTABULA, OHIO

NITRATE CONCENTRATIONS IN TILL WELLS

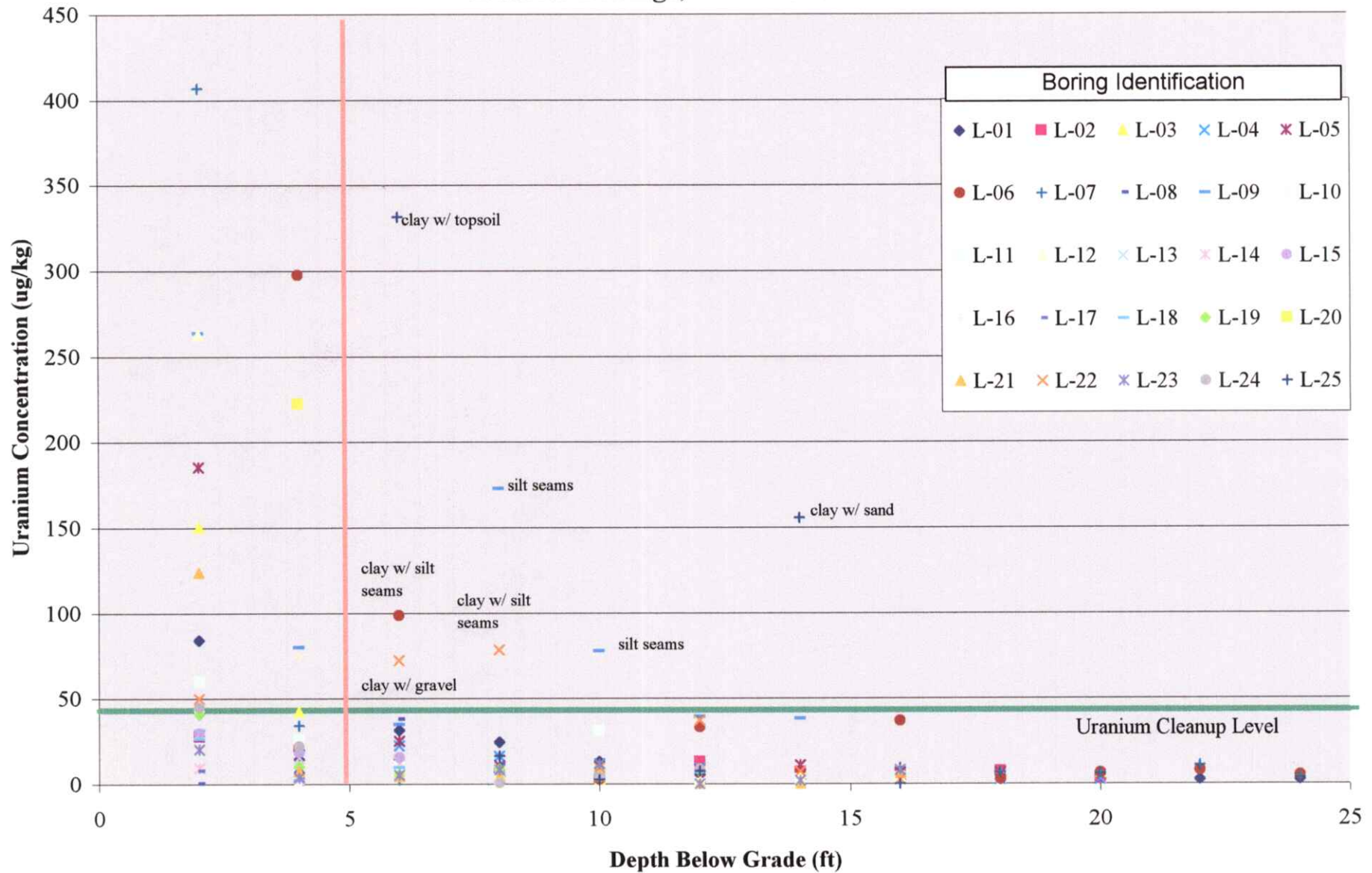
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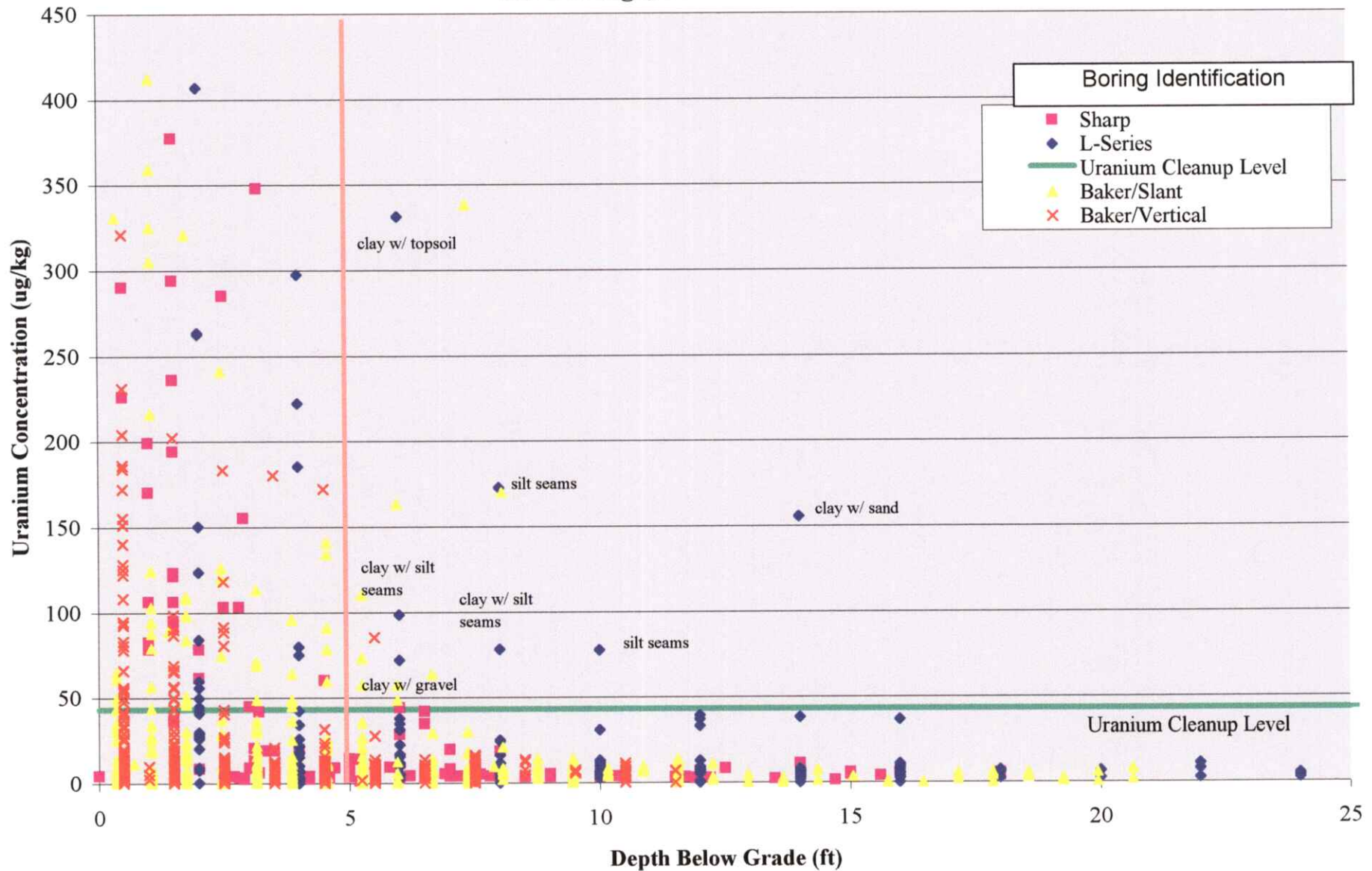
Project No.
2116

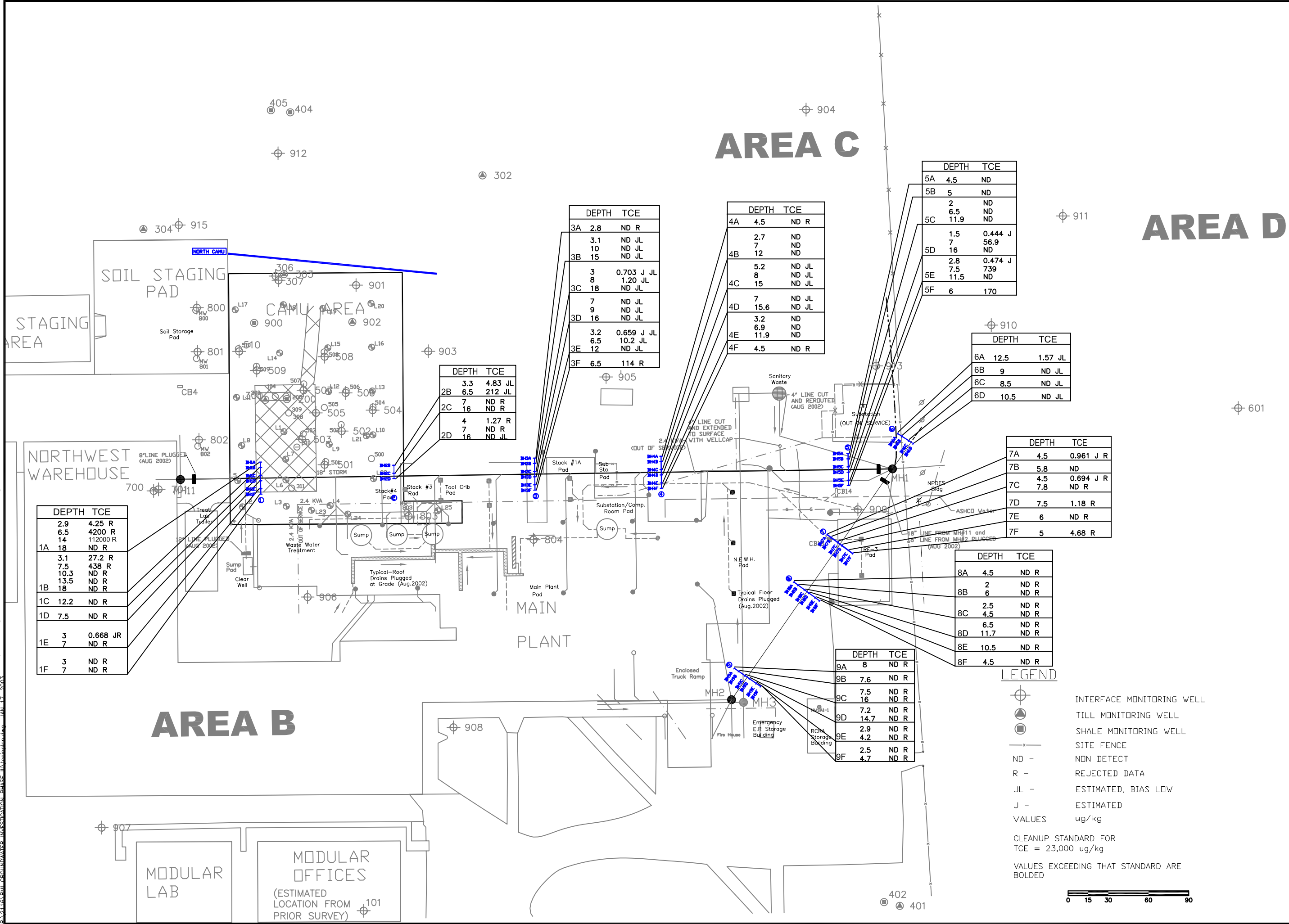
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Figure No. **4.13** Revision **2**

**Figure 5.1. Uranium Concentration vs Depth,
L series Borings, RMI Ashtabula Site**



**Figure 5.2. Uranium Concentration vs Depth,
All Borings, RMI Ashtabula Site**





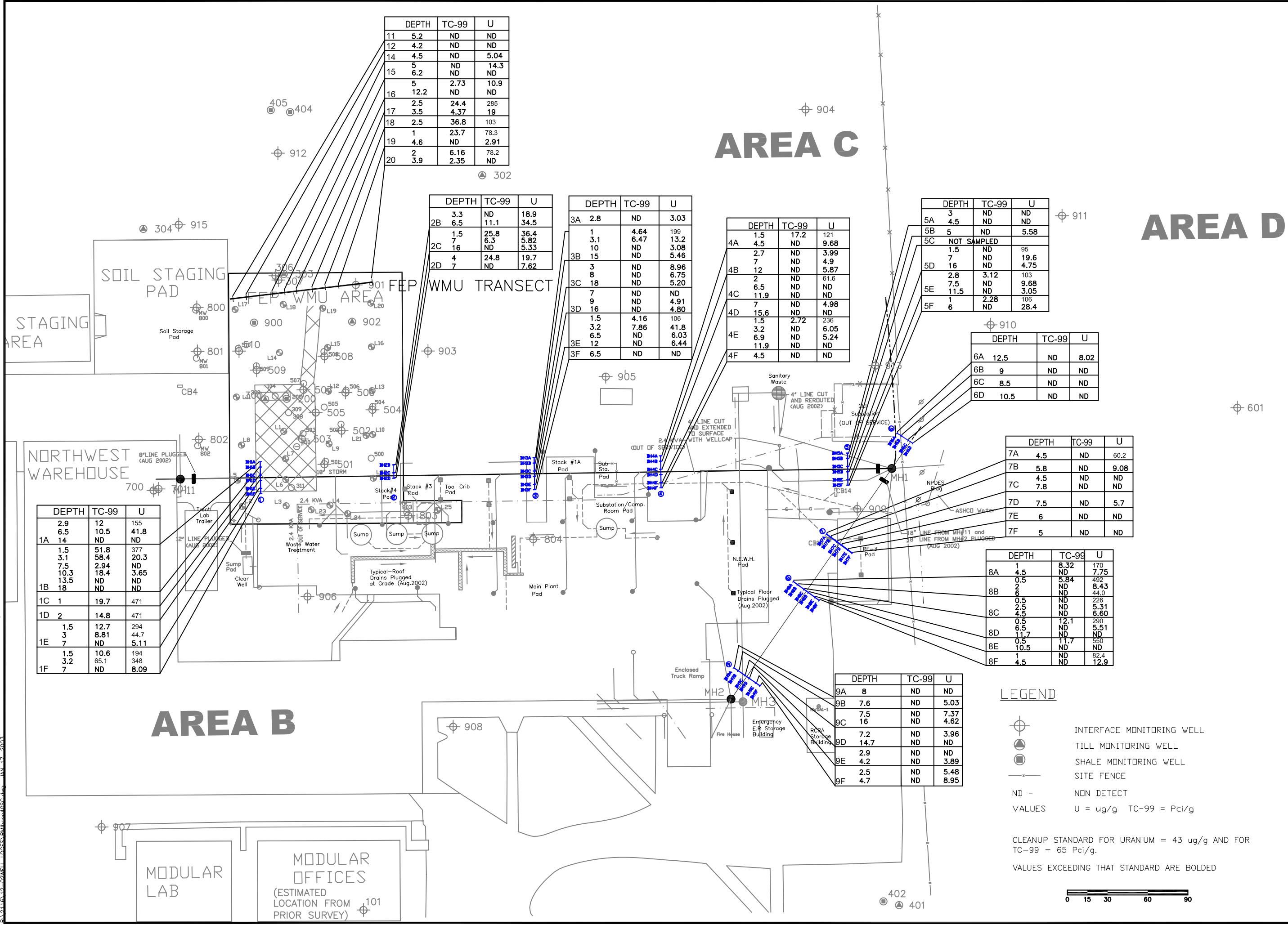
RMI ENVIRONMENTAL SERVICES
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TCE CONCENTRATIONS
IN SOIL



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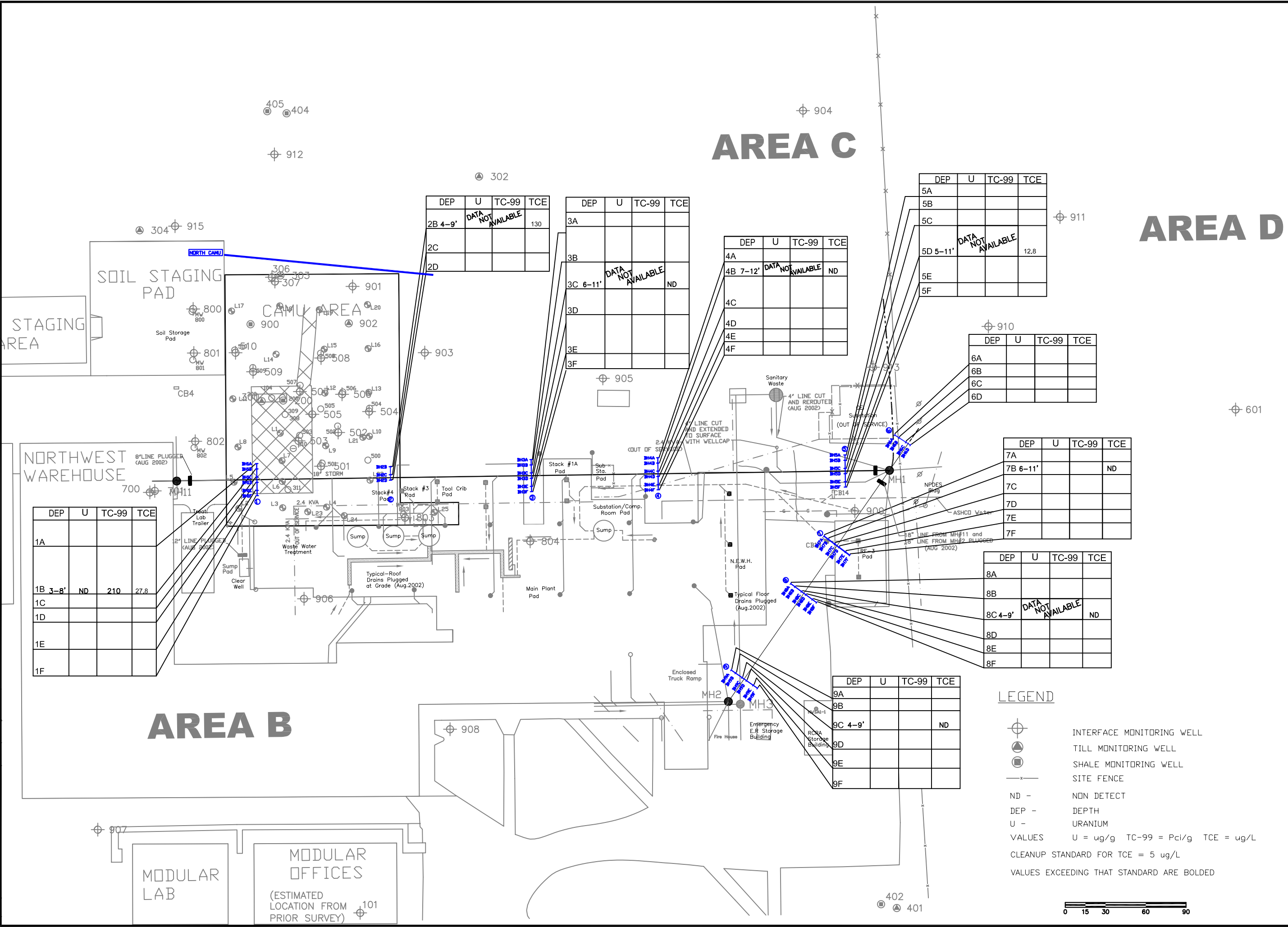
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EXTRUSION PLANT SITE
ASHTABULA, OH

TOTAL URANIUM & TC-99
IN SOILS

[illegible]



RMI ENVIRONMENTAL SERVICES
EXTRUSION PLANT SITE
ASHTABULA, OH

GROUNDWATER CONCENTRATIONS,
TCE, URANIUM & TC-99 FROM
TEMPORARY PIEZOMETERS



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